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Advance of Knowledge Series



MAN'S POSITION IN THE
UNIVERSE :

A ROUGH SURVEY



physics

MAN'S POSITION IN THE UNIVERSE:

A ROUGH SURVEY

BY

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"The great difficulty is always to open people's eyes: to touch their feelings, and break their hearts, is easy; the difficult thing is to break their heads."—RUSKIN'S "ETHICS OF THE DUST."

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PREFACE

OUR subject has never to our knowledge as a whole been handled before.

In venturing to take it up, therefore, it may be well for us to explain the reasons we have for thinking that we can make anything of it. We may point out, then, that our method is to take the store of facts which have been accumulated for us by all the observers, and also the stock of ideas thought out for us by the thinkers.

By bringing the ideas to bear upon the facts, we obtain the effective co-operation both of the thinkers and of the observers. Instead of working single-handed, we have at our back all the great thinkers and all the great observers, if our method is properly worked.

In fact, if due diligence is used in consulting records, and due discrimination used in sifting facts and ideas, and turning to account the failures of the past as well as the successes, and also in avoiding the controversies which have from time to time led others aside out of the straight path, ours is a practical way of bringing the whole strength of humanity to bear upon our subject.

We claim, therefore, that our method of handling our subject is the right one.

We further claim that our procedure is right in so far that we have steadily and continuously worked at our subject, and not endeavoured to dispose of it straight off in one small book.

Beginning with "Light: the Dominant Force of the Universe," and following up with "Force as an Entity," "Argon and Newton: a Realisation," and "The Advance of Knowledge," we have worked up step by step; and with these and minor publications can show a record of twenty-five years of work on our subject, carried on whenever time was available amid the pressure of other duties and cares.

Moreover, we cannot help noticing with the deepest thankfulness that, while we have gone on working, the way has been cleared for us, at least to some extent. When we began working no such thing as an inactive or inert element was known. But at the same time inactive elements are absolutely necessary for our explanation. In fact, all our explanation is based upon them.

In "Force as an Entity," therefore, we were compelled to improvise ideal inactive atoms in the absence of any real inactive atoms. Later on, during the four or five years which elapsed before argon, the first of the inactive elements,

was discovered, we had to make a still more extensive use of inactive atoms. Now we have got five or perhaps six real inactive elements, and therefore so far the way has been opened for us.

At the same time it may perhaps be well to point out that while the four ideal inactive atoms, which we found it necessary at p. 64 of "Force as an Entity" to improvise, weighed respectively 20, 40, 80, and 120; we have now four real inactive atoms weighing respectively 20, 40, 82, and 128, in the atoms of Neon, Argon, Krypton, and Xenon. These values are according to determinations by Professor Ramsay and Dr. Morris Travers,¹ which we shall have to notice again further on. We are well aware that too much stress must not be laid at present on the closeness of the correspondence thus brought out, owing to the extreme difficulty of isolating such things as inactive elements in a pure condition, and thus of obtaining exact determinations of their atomic weights.

We can lay full stress, however, upon the fact that inactive elements now undoubtedly exist, and give us a most important opening.

Then, too, we may point out that while, when we began working, the path of reality was impassable for want of real inactive elements, the

¹ *Chemical News*, vol. lxxxii. p. 258.

way, generally, was also obstructed by the beautiful but unreal vortex atoms, which held the field to the exclusion of the atom of Democritus on which our explanation is built. But here again the way has been opened for us. For the vortex atom is a thing of the past, and it is the atom of Democritus which is now coming to the front, as we gather from the report of a discourse by Lord Kelvin at the meeting of the British Association at Glasgow in 1901, which ends as follows: "We are forced in this twentieth century to views regarding the atomic origin of all things closely resembling those presented by Democritus. . . ." ¹

Thus we find that the situation, so far as the atom is concerned, has become much more real than it was when we began working; and, therefore, in this respect the way has been cleared for us. But we find that the way is also becoming clearer in the direction of energy. For we can now show, as will be seen further on, that in the mechanical interpretation which Davy and Joule respectively gave to the results of their celebrated experiments, a factor of fundamental importance, pointing to directly opposite conclusions, was overlooked both by Davy and by Joule.

In other ways also, as we hope to show further on, the situation is becoming more real in the

¹ *Nature*, vol. lxiv. p. 629.

direction of energy as well as in the direction of the atom.

Then, too, we find that the way is apparently being opened for us in America. For we find in "Atoms and Energies,"¹ published recently, with an introduction by Professor Frederick Starr, of Chicago University, views put forward as to atoms being of certain sizes and shapes, determining their ways of combining, and as to energy being a distinct entity in two forms, together constituting the ether, which in their broad aspect seem identical with the views we have long been putting forward. In detail, indeed, the view adopted in that book, that energy is infinitely divisible, makes energy differ fundamentally from the energy with which we work. It seems possible, however, that the hard logic of facts will show presently that an infinitely divisible energy will have to be replaced by an energy made up of parts, such as that with which we work.

¹ "Atoms and Energies," by D. A. Murray, A.M.

August 18, 1902.

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MAN'S POSITION IN THE UNIVERSE

A ROUGH SURVEY

CHAPTER I

INTRODUCTION

No one who looks at all closely into the present state of our knowledge can fail to be struck with the contrast which becomes manifest between our wonderful success in finding out facts and our failure in finding out the causes to which facts are due.

Our knowledge of facts is ever increasing at a prodigious rate under the labour of a great army of observers in every branch of science; but on the other hand our knowledge of causes is making no progress, or hardly any.

Let us take the following remarks from two authorities whose competency cannot be called in question. "As regards gravitation," says Clerk Maxwell, "the progress made towards the solution of the problem since the time of Newton has been almost imperceptible."¹ And "the question," says

¹ Article, *Attraction*, "Encyclopædia Britannica," ninth edition.

Professor Nernst, "of the nature of the forces which come into play in the chemical union and decomposition of substances, was agitated long before a scientific chemistry existed. As long ago as the time of the Grecian philosophers, the 'love and hate' of the atoms were spoken of as the causes of the changes of matter; and regarding our knowledge of the nature of chemical forces, not much further advance has been made even at the present time. . . .

"To be sure, attempts to form definite conceptions (regarding these affinities) have never been wanting. All gradations of opinion are found, from the crude notion of a Borelli or a Lemery, who regarded the tendency of the atoms to unite firmly with each other as being due to their hook-shaped structure, (and we employ the same view at present when we speak of the 'linking of the atoms in the molecule'), to the well-conceived achievements of a Newton, a Bergman, or a Berthollet, who saw in the chemical process, a phenomenon of attraction which was comparable with the fall of a stone to the earth."¹

Thus we see Clerk Maxwell and Nernst both unable to report any effective progress in our knowledge of causes since Newton's time, and in fact no progress at all apart from Newton so far as the facts connected with Attraction are concerned. The pity of it, one is forced to exclaim, in view of the fact that a knowledge of causes is beyond all question of

¹ "Theoretical Chemistry," translated by C. S. Palmer, p. 353.

infinitely greater importance to us than a knowledge of effects.

Moreover, no excuse for this state of things is to be found in Newton. For Newton said that "... the main business of Natural Philosophy is to argue from phenomena without feigning hypotheses, and to deduce causes from effects. . . ." ¹

And Newton not only said that it was the main business of Natural Philosophy to deduce causes from effects, but gave point to his words by actually doing something himself in the way of deducing causes from effects—something so considerable, in fact, that up to the present, Science, as we have seen from Clerk Maxwell and Nernst, has not been able to get much beyond the point he reached.

Now from what Newton himself says it would appear that the sole reason why he could get no further was simply the want of facts or want of experiments. "To show," he says, "that I do not take Gravity for an essential property of bodies I have added one question concerning its cause, choosing to propose it by way of a question because I am not yet satisfied about it for want of experiments." ²

It was thus want of experiments which hampered Newton's progress. But we have now got facts and experiments in abundance, and yet Clerk Maxwell and Nernst are unable, as we have seen, to find any

¹ "Opticks," third edition, p. 344.

² Ibid., second edition, Advertisement.

effective progress. The reason for this was pointed out by Buckle, and a vehement protest made by him against the procedure to which this state of things is due.

"I cannot," says Buckle, "but regard as the worst intellectual symptom of this great country, what I must venture to call the imperfect education of physical philosophers, as exhibited both in their writings and in their trains of thought. This is the more serious, because they, as a body, form the most important class in England, whether we look at their ability, or at the benefits we have received from them, or at the influence they are exercising, and are likely to exercise, over the progress of society. It cannot, however, be concealed, that they display an inordinate respect for experiments, an undue love of minute detail, and a disposition to overrate the inventors of new instruments, and the discoverers of new, but often insignificant, facts. Their predecessors of the seventeenth century, by using hypotheses more boldly, and by indulging their imagination more frequently, did certainly effect greater things, in comparison with the then state of knowledge, than our contemporaries, with much superior resources, have been able to achieve. The magnificent generalisations of Newton and Harvey could never have been completed in an age absorbed in one unvarying round of experiments and observations. We are in that predicament, that our facts have

outstripped our knowledge and are now encumbering its march. The publications of our scientific institutions, and of our scientific authors, overflow with minute and countless details which perplex the judgment, and which no memory can retain. In vain do we demand that they should be generalised, and reduced into order. Instead of that, the heap continues to swell. We want ideas, and we get more facts. We hear constantly of what nature is doing, but we rarely hear of what man is thinking. Owing to the indefatigable industry of this and the preceding century, we are in possession of a huge and incoherent mass of observations, which have been stored up with great care, but which until they are connected by some presiding idea, will be utterly useless."¹

And now we have in effect an endorsement to some extent of Buckle's protest coming to us from Germany, and coming to us, moreover, from the pen of a great observer and evolutionist. "Unfortunately," says Professor Ernst Haeckel, "this vast progress of empirical knowledge in our 'Century of Science,' has not been accompanied by a corresponding advancement of its theoretical interpretation—that higher knowledge of the causal nexus of individual phenomena which we call philosophy. . . . We have to admit . . . that most of the representatives of what is called 'exact science' are content with

¹ "History of Civilisation," new edition, vol. iii. p. 378.

the special care of their own narrow branches of observation and experiment, and deem superfluous the deeper study of the universal connection of the phenomena they observe.”¹

Now it is plain that a knowledge of facts, even if it were quite complete, could only at best be half knowledge without a knowledge of causes. And yet we are intent upon bringing this half-knowledge to the door of every one by insisting upon universal education. That it will prove indigestible to many cannot be doubted, and that it will satisfy none cannot be doubted either.

The wonders Science has to show are so many and so great that men are necessarily fascinated when they are displayed before them. Already men in vast numbers all the world over have come under this fascination, and, discarding old beliefs, are now looking to science for guidance. And when these wonders are brought to the door of the millions by universal education, the effects will be far-reaching indeed, especially when men come to realise the fact that Science has no explanation to offer of the wonders it has to show, and thus can only unsettle and not decide.

There will be a general loosening of the old bonds without any formation of new ties to replace them. The pity of it, one is forced to

¹ “The Riddle of the Universe,” Author’s Preface, p. xi., translated by J. McCabe.

exclaim again, in view of the inability of Science to rise to the occasion, and in view of the tremendous consequences which may be involved in such failure.

If it is objected that Mr. Herbert Spencer has done all that is necessary and given us all that we need in his Philosophy, we have only to turn to Mr. Herbert Spencer himself for a sufficient reply.

He tells us that he is "placed at a disadvantage in having had to omit that part of the System of Philosophy which deals with Inorganic Evolution," and adds that "in the original programme will be found a parenthetical reference to this omitted part, which should, as there stated, precede the *Principles of Biology*. Two volumes are missing."¹

Thus Mr. Herbert Spencer tells us that his System of Philosophy is incomplete.

Now Mr. Herbert Spencer has told us also that the disagreements between Religion and Science "have throughout been nothing more than the consequences of their incompleteness."²

The inference, therefore, is obvious that if Mr. Herbert Spencer's System of Philosophy were completed there is a possibility that its conclusions would be very different from what they are now.

At all events it is sufficiently clear that Mr. Herbert Spencer's System of Philosophy does not supply all that is necessary.

¹ "Biology," revised edition, vol. i. Appendix D, p. 696.

² "First Principles," fifth edition, p. 105.

Now, Professor Ernst Haeckel has gone to the root of the whole matter as it seems to us. "We must welcome," he says, "as one of the most fortunate steps in the direction of a solution of the great cosmic problems, the fact that of recent years there is a growing tendency to recognise the two paths which alone lead thereto—*experience* and *thought* or *speculation*—to be of equal value, and mutually complementary. . . . For these two great paths of knowledge, sense-experience, and rational thought are two distinct cerebral functions; the one is elaborated by the sense-organs and the inner sense-centres, the other by the thought-centres, the great 'centres of association in the cortex of the brain,' which lie between the sense-centres. . . . True knowledge is only acquired by combining the activity of the two. . . .

"This one-sided over-estimation of experience is as dangerous an error as the converse exaggeration of the value of speculation. Both channels of knowledge are mutually indispensable."¹

To our mind, Professor Ernst Haeckel's observation, that observing and thinking are different cerebral functions and have different centres in the brain, makes it clear that we must take in hand the work of thinking more systematically than we have hitherto done if satisfactory results are to be secured. We train men very diligently and

¹ "The Riddle of the Universe," translated by J. McCabe, p. 18.

carefully to observe, but is it not a fact that we neglect altogether to train men to think?

And yet Professor Ernst Haeckel's observation, that observing and thinking have different centres in the brain, goes to show that men require to be trained in thinking in order to develop their powers of thought just as much as they require to be trained in observing in order to develop their powers of observation.

The Germans have a saying that "dreaming is easy and thinking is hard" as Professor James Ward tells us.¹

Well, then, if thinking is hard, we manifestly require training for it as we do for other kinds of hard work.

May we not, indeed, see in our neglect to train men in thinking an explanation of the strange remark Buckle makes in regard to thinkers and observers? "For one person," says Buckle, "who can think, there are at least a hundred persons who can observe. An accurate observer is, no doubt, rare; but an accurate thinker is far rarer. Of this the proofs are too abundant to be disputed."²

In fact, our contention is that we need to take up thinking in the same systematic way as we have taken up observing, and that we need accordingly to organise a staff of thinkers to take in hand and

¹ "Naturalism and Agnosticism," vol. ii. p. 42.

² "History of Civilisation," vol. iii. p. 463.

deal systematically with the facts accumulated by the noble army of observers.

If we are right, and a change is absolutely necessary, surely the opening of a new century is a fitting time for a departure of this kind.

At such a juncture we cannot but regard it as a most fortunate circumstance that the Presidential address to the Bradford Meeting of the British Association on the 6th September 1900—the meeting which was, at all events, the one which came nearest to the opening of the new century—forcibly impressed upon Science the necessity of thinking as well as observing. “In scientific research, also,” said Professor Sir William Turner in that address, “diligence and accuracy are fundamental qualities. By their application new facts are discovered and tabulated, their order of succession is ascertained, and a wider and more intimate knowledge of the processes of nature is acquired. But to decide on their true significance a well-balanced mind and the exercise of prolonged thought and reflection are needed.”¹

Then, too, from across the Atlantic there has come to us a stirring address, pointing very much in the same direction. We refer to the address given by Dr. D. J. Hill, Assistant-Secretary of State, on a Commemoration Day at the Johns Hopkins University, which also came at the opening

¹ *Nature*, vol. lxii. p. 440.

of the new century. We note that Dr. D. J. Hill in his address remarked that "in the moment of perplexity it is to some quiet scholar or studious thinker that the nation makes appeal; and when he speaks, light dawns, the clouds are swept away, and the path of action is made plain. . . ."

"Give us then," Dr. Hill went on to say, "O learned doctors, more discoveries of science, for we know not what new revelations may yet burst forth from your laboratories . . . give us more of ethics and philosophy, for it is only in the light of great principles that character becomes firm and conduct noble; let earth, and sea, and sky, and the stars in their courses, the long struggle of man and the story of his aspirations, the tongues of the busy day and the silence of the voiceless night, the instincts that stir us to passion and the still small voice that drops its calm out of eternity, all teach us the ways of creation and the mystery of our divine descent; for it is through the totality of their culture that nations rise, and through ignorance or defiance of unbending laws that nations fall."¹

So far, then, as our procedure is concerned, we find reason to believe that the necessity of doing more in the way of thinking is beginning to be recognised. And so far as that portion of our results which points to the correctness of the atomic theory and to the existence of the hard

¹ *Nature*, vol. lxiv. p. 118.

atom of Democritus is concerned, we rejoice to find, that at the meeting of the British Association at Glasgow last year, the President in his address declared plainly for the atomic theory; but far more do we rejoice to find Lord Kelvin, at the same meeting, declaring plainly for the atom of Democritus, if the report of the discourse delivered by him in the Mathematical and Physical Section is correct. He is reported to have stated that we are forced in this twentieth century to views regarding the atomic origin of all things closely resembling those presented by Democritus, Epicurus, and their majestic Roman poetic expositor, Lucretius.¹

This is good news indeed.

In fact, the outlook for reality is becoming much brighter than it was before.

We can get, as we have already shown repeatedly before, a form for the hard atom which makes it a reality, and we can get also a real form for the energy corpuscle which makes energy a reality also.

Thus we get real atoms in a real environment, and therefore a real Universe.

If we can get an accurate survey of a real universe, we may hope to be able to lay down accurately our position as realities in it.

We shall indeed have to go over ground we have surveyed before. But since our last survey some

¹ *Nature*, vol. lxiv. p. 629.

prominent points have become much clearer and better known, and we can now test the accuracy of our work by these.

For instance, Professor Ramsay has given determinations of the weights of the atoms of the Inactive Elements, Helium, Neon, Argon, Krypton, and Xenon, and these determinations, as we hope to point out further on, show inactive elements almost exactly in the positions assigned to them in our survey. Argon, indeed, is a little out, though exactly in the position found by us for an ideal inactive element in "Force as an Entity"¹ before any real inactive elements were known.

And now we are, as we hope to point out further on, able to show that in one of the two kinds of fluid energy corpuscles we have deduced we have Newton's "Agents in Nature able to make the particles of bodies stick together by very strong Attractions."²

If we remember that Newton said that it is "the business of Experimental Philosophy" to find out these agents;³ if we remember also the fact pointed out at page 2 that Clerk Maxwell's and Nernst's remarks quoted there show, when taken together, the remarkable fact that science has been unable to arrive at any explanation of attraction away from Newton, and unable to make any effective

¹ Page 64.

² "Opticks," third edition, p. 369.

³ Ibid., p. 369.

progress beyond the point Newton reached: then the importance of the fact that we are able to show that we are working with Newton's "Agents in Nature" in our explanation of attraction, will be manifest.

In addition to this we believe, for reasons we hope to give further on, that we shall be able to show that the corpuscles with mass about the $\frac{1}{1700}$ th part of the mass of a hydrogen atom which Professor J. J. Thomson finds in kathode rays and Sir William Crookes's radiant matter, are both in reality energy corpuscles, and, in fact, Newton's agents in Nature.

We do not think, therefore, that we are wasting time in making sure of our ground, and in endeavouring to drive home the facts which the Periodic System, if we are right, shows so clearly. At the same time we must, to use Mr. Herbert Spencer's expression, bespeak a little patience.

CHAPTER II

BELOW EVOLUTION

WE find that Science recognises two realities only in the Universe, namely, Matter and Energy.

Let us look into this point. For it is plain that if there are two realities only real knowledge must take account of one or other, if not of both of them, otherwise it cannot be real.

Let us see, then, what Science has to tell us in regard to this. On turning to Professor Rankine's work, we find the following statement:—

“We must now,” he says, “say a word or two on the question of the objective realities in the physical world. If we inquire carefully into the grounds we have for believing that matter (whatever it may be) has objective existence, we find that by far the most convincing of them is what may be called the ‘conservation of matter.’ This means that, do what we will, we cannot alter the mass or quantity of a portion of matter. We may change its form, dimensions, state of aggregation, &c.; or (by chemical processes) we may entirely alter its appearance and properties, but its quantity

remains unchanged. It is this experimental result which has led, by the aid of the balance, to the immense developments of modern chemistry. . . . The only other known thing in the physical universe, which is conserved in the same sense as matter is conserved, is energy. Hence we naturally consider energy as the other objective reality in the physical universe, and look to it for information as to the true nature of what we call force.”¹

In regard to these realities Professor Tait tells us that “Matter is simply passive (*inert* is the scientific word); energy is perpetually undergoing transformation. The one is, as it were, the body of the physical universe; the other its life and activity.”²

Thus we find that Matter and Energy are the only realities which Science recognises.

Now our point is that Science by its discoveries has got down below Evolution in connection with both of these realities. Let us look into this then; for, if the case is really so, it is plain we cannot start with Evolution if our inquiry is to have any pretension to thoroughness.

In the case of Matter we find that Science has got down below Evolution by the Periodic System.

The facts are briefly these:—

Chemistry shows that all solid substances known

¹ Article *Mechanics*, “Encyclopædia Britannica,” ninth edition, p. 747.

² “Properties of Matter,” second edition, p. 7.

to us can be converted into gases, or vapours as they are sometimes called, and also that all gases known to us (with the exception of Helium) can be solidified; and thus that there are two principal states of matter, namely, the gaseous and the solid states, which all kinds of matter can assume when circumstances are favourable. We may note that the liquid state, which is intermediate between the gaseous and the solid state, is not necessarily assumed by matter in passing from the one state to the other, and therefore is not of the same importance as the other two states.

Chemistry further shows that all the thousands upon thousands of substances known to us, whether occurring as gases, liquids, or solids, or belonging to animate or inanimate bodies, are made up of some seventy different elementary substances, or elements as they are called.

It also shows that each of these elementary substances is made up of minute atoms in prodigious numbers, and so small in size as to be altogether invisible even under the most powerful microscope we can produce.

Chemistry further shows that each of these elementary substances has an atom peculiar to itself which, though exactly like every atom of its own kind, differs in weight and in specific heat and in its spectrum from every atom of every other kind.

It shows further that in the formation of all bodies and masses the first stage is the building up of molecules or groups of atoms, each consisting of two or more of the atoms of these elementary substances united together with perfect order and regularity, although some of these molecules, such as the highly complex molecules of organic substances, are made up of hundreds of atoms.

After a sufficient number of molecules have been formed masses are then built up out of the molecules just as molecules are built up out of atoms.

A compound substance has at least two kinds, and may have half-a-dozen or more kinds of atoms in its molecule.

Each compound substance has a molecule peculiar to itself, and differing from the molecule of any other substance, just as each elementary substance has an atom peculiar to itself and differing from the atom of every other substance. At the same time all the molecules of each of the compound substances are exactly like all other molecules of that substance both as regards the kind of atoms and the number of atoms of each kind present in the molecule, and as regards the way the atoms are arranged in the molecule.

Looking then at atoms as the materials out of which molecules are built, Chemistry further shows that atoms differ in value as materials for building

molecules, or differ in valency, as the chemist calls their value for molecule building. This difference in building value comes out in the following way. When two elementary substances combine to form a binary compound, that is to say, a compound substance with molecules composed of atoms of two kinds only, such, for example, as water, which has molecules composed of two atoms of hydrogen gas united to one atom of oxygen gas, it is found that the atoms of some elementary substances can singly take on more atoms of another substance than others can take. We have seen above that in forming a water molecule a single atom of oxygen takes on two atoms of hydrogen. Two, in fact, is the greatest number of atoms of any other substance which a single atom of oxygen can take on in binary combination. Oxygen is therefore called in Chemistry divalent, which means able to take two. But while the oxygen atom cannot take on more than two atoms of another substance, there are other substances with atoms able to take on as many as four atoms of another substance. Thus carbon combines with hydrogen to form marsh gas, or methane as it is called in Chemistry, with molecules consisting of one atom of carbon united to four atoms of hydrogen. Carbon is therefore called in Chemistry a *tetra-valent* or four valent. Again, there are other substances with atoms which cannot take more than three atoms of another substance. Thus nitrogen combines with hydrogen

to form ammonia with molecules, each of which has one atom of nitrogen combined with three atoms of hydrogen. Hence nitrogen is called in Chemistry trivalent or three valent.

Lastly, there are other substances with atoms which take on one other atom only. Thus the gas chlorine combines with hydrogen to form hydrochloric acid with molecules, each of which consists of a single atom of chlorine united to a single atom of hydrogen. Accordingly, chlorine is called in Chemistry a monovalent or one valent substance.

Thus we see that atoms viewed as building materials, that is to say, as materials for building molecules, have different values for building purposes, some being able to take on one atom only, others being able to take on two, others being able to take on three, and others to take on four.

Four is the greatest number of atoms which can normally be taken on in binary combination. Five and even six atoms are actually taken up in some cases, but these, as shown in page 68 of "The Advance of Knowledge," may be taken to be abnormal cases.

It is, of course, if we think over it, a marvellous circumstance that these things so minute as to be quite invisible under the best microscope, should take on other atoms with such regularity and certainty, and moreover should differ from each other

in the number of atoms they can take on and thus in building value.

However, it is at this stage the Periodic System comes in and takes the atoms when their weights and building values or valencies have been determined. It arranges the elementary substances, in fact, in the order of the weights of their atoms, and then marks upon each its building value or valency, so that the chlorine atom, which takes one other atom only, as shown above, is marked 1; oxygen, which as shown above takes two other atoms, is marked 2; nitrogen, which takes three other atoms, is marked 3; carbon, which takes four other atoms, is marked 4; and so for the rest, each being marked 1, 2, 3, or 4, according to its valency or building value. It then shows that the list so obtained is simply a repetition over and over again of series of two kinds, one consisting of metals and the other of metalloids. Each of these series, when complete, consists of four terms or members, one of which has a valency or building value of 1, another a valency or building value of 2, another of 3, and the last of 4.

The difference between the two series is that in the metal series, the member having a valency or building value of 1 has a lower weight than the member with a building value of 2, the member with a building value of 2 a lower weight than the member with a building value of 3, and the member with a building value of 3 a lower weight than

the member with a building value of 4; while in the metalloid series exactly the opposite arrangement prevails, and the member with a building value of 1 has a higher instead of a lower weight than the member with a building value of 2, and the member with a building value of 2 a higher instead of a lower weight than the member with a building value of 3, and so on.

It thus becomes apparent that the Periodic System brings out the most extraordinary and most important fact that atoms are only made available for building purposes, that is to say, for the purpose of building molecules by undergoing alterations which affect their weight such that the higher the building value of an atom the greater is the amount of alteration it has to undergo.

The alteration involves an addition to the weight of the atom if the element belongs to the Metal class of substances, such as copper, silver, gold, &c., and a reduction in the weight of the atom if the element belongs to the non-Metal or Metalloid class of substances—sulphur, phosphorus, &c. Now, we know that our own building materials have generally to be altered in one of these two ways in order to make good joints with them.

If they are non-metallic substances, such as stone, wood, &c., we have to face them or square them by cutting them down at the joints and thereby reducing their weights.

If they are metallic substances, such as plates of iron, we have in many cases to attach other pieces, such as lengths of angle iron, to them in order to join them together, and thus have to make additions by which their weights are increased.

Then, too, with our materials provision has to be made separately for each joint by an alteration which affects the weight of the raw material either by reducing or increasing its weight, so that each additional joint involves an additional increase or reduction in weight.

Thus if we want to join two strips of plate iron together to form a V-shaped trough, we have to attach one length of angle iron, thereby increasing weight.

If we want to join three plates so as to make a rectangular trough, we attach another length of angle iron to one of the plates, thereby making a further addition to its weight, and so on.

But this, as we gather from the series in the Periodic System, is very much what was done to the metal atom to prepare it for molecule building. For its weight shows, when it is compared with the weights of the other members of its series, that the atom has undergone alterations which have affected its weight by increasing it by a separate amount for each additional atom taken on by it in molecule building, and thus for each additional joint. Thus in the first series in the Periodic System, the

lithium atom, weighing 7 and taking on 1 atom, has a higher weight than the inactive helium atom, weighing 4 and taking no atom; the beryllium atom, weighing 9 and taking two atoms, has a higher weight than the lithium atom; and the boron atom, weighing 11 and taking 3 atoms, has a higher weight than the beryllium atom; and in each of the other Metal series we find a similar relation holding between the members of a series. In fact we shall see further on that the Metal series of the Periodic System are comparable with the series in the lists of articles manufacturers turn out. And if we take non-metallic materials we find that rough blocks of stone are cut down or dressed on one side, and thus lose weight if one bed or face is required, as for a rough cap or coping-stone; and are dressed on two sides and thus undergo a further loss in weight if two beds or faces are required, and so on. But this again is, as we gather from the Metalloid series in the Periodic System, very much what happened to the Metalloid atom when it was being prepared for molecule building. For its weight, when compared with the weights of the other members of its series, shows that it was prepared for molecule building by undergoing alterations which affected its weight by reducing it by a separate amount for each additional atom taken on by the atom in molecule building. Thus in Series 2, the fluorine atom, which takes on 1 atom in

molecule building with hydrogen, and weighs 19, has a lower weight than the inactive Neon atom which weighs 20 and takes on no atom; the oxygen atom, weighing 16 and taking on 2 atoms, has a lower weight than the fluorine atom; the nitrogen atom, weighing 14 and taking on 3 atoms in molecule building, has a lower weight than the oxygen atom. And again the carbon atom, weighing 12 and taking on 4 atoms, has a lower weight than the nitrogen atom.

We are shown, in fact, in the Periodic System, as completed by Dr. Ramsay's work, raw materials in the shape of inactive elements with which no molecules can be built, and therefore no Evolution is possible, converted into valent atoms suitable for molecule building by operations analogous to those which confront us in manufacturers' and builders' yards.

By the discovery that inactive elements exist Science gets down below Evolution, and there is no getting from inactive elements to valent elements, and thus to Evolution without manufacturing operations. In other words, Creation alone and not Evolution, can explain the origin of the universe.

Indeed, we do not come upon Evolution at all in connection with the first stage in the building of the universe, namely, the stage in which atoms were prepared for molecule building.

And even when the atoms were ready for

molecule building, we still do not come at once upon Evolution. In fact, we do not come upon Evolution until yet another Age elapsed. We have stated that Science has got down by its discoveries below Evolution, not only in connection with Matter by the Periodic System, but in connection with the other reality, Energy, also. Accordingly, we find that Science shows us, by the Kinetic Theory of Gases, the atoms after they had been prepared and got ready for molecule building, not put together and made up into molecules, but scattered and dispersed throughout Space. We find the atoms thrown into a state of wild chaotic motion with which no form is possible, and with which, accordingly, there is no place for Evolution.

By the Periodic System we are shown an Age of Creation, an Age of Preparation; by the Kinetic Theory of Gases we are shown an Age of Dispersion.

We turn therefore now to the Kinetic Theory of Gases, which may be said to be as firmly established as Evolution, and we learn that it shows us that—"The particles of a gas—which are identical with the chemical molecules—are practically independent of each other, and are briskly moving in all directions in straight lines. It frequently happens that the particles encounter each other, and also the walls of the vessel containing them; but as both they and the walls are supposed to behave like

perfectly elastic bodies, there is no loss of their energy of motion in such encounters, merely their directions and relative velocities being changed by the collision.¹

But we must go down below real gases—below the gases which are about us.

The vast majority of real gases are made up of molecules, and thus of atoms with which building work has been already done so far that molecules have been already evolved. Gaseous molecules, indeed, continue to move almost as if they were separate atoms; but we are manifestly not below Evolution in a gas which is formed of molecules.

A few gases, such as mercury vapour and the inactive gases, Helium, Neon, Argon, &c., are mon-atomic, that is to say, have atoms existing separately, and it is by these we must get down.

But we must get down below even these, for their atoms are all under the influence of attraction and are therefore not perfectly independent of each other. We must get down, in fact, to ideal gases, in which the atoms are perfectly independent of each other except when they collide.

Mr. Herbert Spencer tells us that Evolution under its simplest and most general aspect is the integration of matter and concomitant dissipation of motion.²

¹ "Introduction to Physical Chemistry," by Prof. James Walker, first edition, p. 84.

² "First Principles," fifth edition, p. 285.

But the Kinetic Theory of Gases shows us, as we have seen above, gases made up of particles independent of each other "briskly moving in all directions in straight lines." And, though these particles "frequently encounter each other, there is no loss of their energy of motion in such encounters, merely their directions and relative velocities being changed," because they are "supposed to behave as perfectly elastic bodies." Since, therefore, the atoms, even when they come together in collision, do not remain together but fly off independently of each other, it is plain that no integration of matter is possible in an ideal gas; and since, also, "there is no loss of their energy of motion" when the atoms come together in collision, it is further plain that no dissipation of motion takes place, but instead the atoms persevere in their wild chaotic flight. It is, therefore, clear that in an ideal gas in the state in which the Kinetic Theory of Gases exhibits it, "no integration of matter with concomitant dissipation of motion" is possible, and also no evolution unless a change takes place.

The Kinetic Theory of Gases, therefore, shows us atoms scattered and dispersed throughout Space instead of being utilised for molecule building, for which they were prepared, as the Periodic System shows us, and thus the object for which the atoms were prepared completely lost sight of.

We are shown building materials made quite ready for building operations, but carried off and scattered and kept in a state of dispersion, so that no building operations are possible with them.

In fact we come upon Antagonism and not upon Evolution. And, moreover, we come upon an Antagonism so pronounced that the atoms cannot be recovered and made available for building purposes without an actual conflict.

The Periodic System and the Kinetic Theory of Gases both take us down below Evolution and show us an "Earth without form," that is to say, they show us the materials required for building our earth all prepared and got ready for building, but not put together, only chaotically mixed up together.

But we know, or believe we do, what the change was which made Evolution possible. It was, in fact, the advent of Attraction.

Now Newton, as we have seen at page 13, has pointed out that there are "Agents in nature able to make the particles of bodies stick together by very strong Attractions,"¹ and has also stated in his third letter to Bentley that "gravity must be caused by an agent."

Hence we gather from Newton that it was the advent of agents able to make the particles of bodies stick together with a very strong attraction which

¹ "Opticks," third edition, p. 369.

put a restraint upon the state of wild chaotic motion amongst the atoms which the Kinetic theory reveals.

The doctrine of the Conservation of Energy teaches us that Energy cannot be destroyed but only transformed or transferred. Hence we conclude that the Kinetic Energy, which keeps the atoms in the state of chaotic motion which the Kinetic Theory of Gases reveals, had to be dislodged from its position about the atoms and transferred to another side of Space; and that its place had to be taken by Attractive Energy, which draws atoms together before any building work could be done with the atoms and before Evolution could appear.

Hence we find the order of succession to be: first, Creation, next, Antagonism, and then Evolution.

CHAPTER III

CREATION

MR. HERBERT SPENCER makes, amongst other remarks on the subject of Creation, the following statement: "Alike in the rudest creeds and in the cosmogony long current among ourselves, it is assumed that the genesis of the Heavens and the Earth is effected somewhat after the manner in which a workman shapes a piece of furniture. And this assumption is made not by theologians only, but by the immense majority of philosophers past and present. Equally, in the writings of Plato, and in those of not a few living men of science, we find it taken for granted that there is an analogy between the process of creation and the process of manufacture. Now, in the first place, not only is this conception one that cannot, by any cumulative process of thought, or the fulfilment of predictions based on it, be shown to answer to anything actual; and not only is it that in the absence of all evidence respecting the process of creation, we have no proof of correspondence even between this limited conception and some limited

portion of the fact; but it is that the conception is not even consistent with itself.”¹

In reference to this we must endeavour to show that the “evidence respecting the process of creation,” which was wanting when Mr. Herbert Spencer wrote, is now forthcoming in the Periodic System, as completed by the discovery that inactive elements are actually in existence; and that the consensus of opinion in favour of Creation which Mr. Herbert Spencer noticed is warranted by facts.

We must endeavour to show that in the light of the further discoveries which Science has made, the case looks quite differently now to what it looked a few years ago.

Science is, in fact, becoming more complete, and is coming more nearly into agreement with Religion. And thus facts are justifying the remark which Mr. Herbert Spencer has made, as already pointed out, to the effect that the disagreements between Religion and Science “have throughout been nothing more than the consequences of their incompleteness.”² The fact is, we have been building upon Evolution without examining its foundations, and making sure that they were good enough to carry the immense superstructure we were raising. And now it is becoming apparent that the foundations of Evolution are in reality not half as deep as they

¹ “First Principles,” fifth edition, p. 33.

² Ibid., p. 105.

have been supposed to be. This is brought out by the Periodic System, which, in our judgment, puts before us facts of the highest importance for the right understanding of the situation confronting us all here as reasonable human beings.

We may be excused, therefore, for dwelling upon these facts, and going over them again and again in the hope of driving their significance home.

The case seems to us so beautifully clear and simple, that no one can fail to grasp it who will take the trouble to look into it, and compare the facts which the Periodic System of chemistry sets forth with those which confront us in everyday life in connection with the building operations which are going on about us.

At the same time, we recognise that one of the great difficulties in driving the case home in these days of specialising lies in the fact that chemists and physicists have at hand a ready excuse for not looking into the case, in the fact that it has to do with building operations, and thus has to do more or less with engineering. For our part, we take the Periodic System, dry as it appears at first sight, to be the greatest discovery, so far as the advancement of our knowledge is concerned, that Science has ever made.

We have endeavoured to show in the preceding chapter, briefly at p. 21, how and where the Periodic System comes in, and also the nature of the two

kinds of series, namely, Metal and Metalloid, which it sets forth.

It will be remembered that we pointed out that each of the series, whether Metal or Metalloid, of which the system is made up, consists in a complete form of four members, one of which takes on one other atom in forming molecules in the shape of groups of atoms of binary compounds; while another takes on two other atoms; another three; and another four.

Keeping this in view, we perceive that the facts are in accordance with the view that a simple structural relation subsists between the different members of each of these series, and when we look closer we are confirmed in the opinion that it is really a relation of a structural kind by the fact that the weight of the atom is affected by it.

It is this structural relation which we want now to investigate. Now the first of the series in the Periodic System is a Metal series, of which the first member is lithium, with an atom which takes on 1 atom only, and thus has a building value of 1, and weighs in round numbers 7; the second member is beryllium, with an atom which takes 2 atoms, and thus has a building value of 2 and weighs 9; the third member is boron, with an atom which takes 3 atoms, and has a building value of 3 and weighs 11; the fourth member of this series is not at present known.

Now, plainly, we have in this, the first of the Metal series, strong internal evidence that the whole series originated from the atoms of an inactive element, weighing each 5, by a process of putting on seats, weighing each 2, to the inactive atoms, which were inactive simply for want of seats in which to accommodate other atoms, and were consequently unable to take on any atoms at all.

Let us take the third member of the series, viz. boron. This has atoms weighing 11, with a building value of 3, showing that it has seats for 3 atoms. Thus the boron atom, taking on 3 atoms, has a weight greater by 2 than the beryllium atom, which takes on 2 atoms only, and weighs 9. Hence we see that there is evidence that the boron atom gained 1 seat more than the beryllium atom, by a piece weighing 2 being put on to an atom with 2 seats, weighing 9.

Again, the boron atom, taking on 3 atoms, has a weight greater by 4, or twice 2, than the weight of the first member of its series, the lithium atom, which takes on 1 atom only and weighs 7. Thus we have evidence that the boron atom gained 2 of its seats by an alteration which added 4 to its weight. But from the beryllium atom we have already evidence, in regard to 1 of these 2 seats, that it was made by a piece weighing 2 being put on to an atom with 2 seats, weighing 9. Hence we have now evidence that the boron atom gained

2 seats more than the lithium atom by having 2 separate pieces, weighing each 2, put on to it.

Since we have thus from the boron atom direct evidence, in regard to the second and third seats put on, that each of them weighed 2, we may reasonably assume that the first seat put on to it also weighed 2. Thus we have evidence that an inactive element, with atoms weighing each 5, and having no building value for want of seats on which other atoms could sit upon them, was converted into boron with atoms with a building value of 3 by having 3 seats, each weighing 2, put separately on to each of its atoms, thereby increasing the weight of its atoms to 11.

In the case of the second member of the series, viz., beryllium, with atoms weighing 9, and taking on 2 other atoms, there is the same evidence that the 2 atoms which its atoms take on were provided each with a separate seat by putting on 2 pieces, each weighing 2, to the atoms of an inactive element, each weighing 5, as there is, as we have seen, that 2 of the atoms which the boron atom takes on were each provided with a separate seat by putting on 2 pieces, weighing each 2, to the atoms of an inactive element, each weighing 5.

In the case of the first member of the series, viz., lithium, which has atoms weighing 7, and each taking on 1 other atom, there is the same reason to infer that the 1 atom which its atoms take

on was provided with a seat by putting on a piece weighing 2 to the atoms of an inactive element, each weighing 5, as there is to infer that the first of the 3 atoms which the boron atom takes on was provided with a seat by putting a piece weighing 2 on to the atom of an inactive element with atoms weighing each 5.

We have now a complete case. For we have the whole series of active or valent elements derived from an inactive element, with atoms weighing 5, and having no seat on which other atoms can sit, in one and the same way, namely, by putting on to the atoms of the inactive element pieces weighing each 2 to furnish a separate seat for each atom which the active or valent element takes on.

Thus the inactive atoms, weighing each 5, were converted into lithium atoms weighing 7 and taking on 1 atom by putting 1 piece weighing 2 on to the inactive atoms weighing 5, thereby increasing their weight to 7. Again, the inactive atoms weighing each 5 were converted into beryllium atoms weighing each 9, and taking on each 2 other atoms by putting on 2 pieces weighing each 2 to the inactive atoms weighing 5, thereby increasing their weight to 9. Again, the inactive atoms weighing each 5 were converted into boron atoms weighing each 11, by putting on 3 pieces weighing each 2 to the inactive atoms weighing 5, thereby increasing their weight to 11.

The case as it stands thus has been completed, and thus vastly strengthened, by Dr. Ramsay's discovery of the inactive element, helium, having atoms weighing about 4, as shown in a paper on "Argon and its Companions," by William Ramsay, F.R.S., and Morris W. Travers, D.Sc., read before the Royal Society, 15th November 1900.

It is, of course, possible that when helium is further purified the weight of its atom will rise to 5. If this should happen, we should then have a perfectly symmetrical case. If, however, the true weight of helium should turn out to be 4, the conclusions drawn above will have to be modified so far, that the weight of the first seat put on to make the non-valent helium atom weighing 4, and taking on no atom, into the valent lithium atom weighing 7 and taking on 1 atom, will have to be taken as 3 and not as 2 as we have assumed above.

This, however, will not disconcert us at all, because the other Metal series show that the weight of a seat is not always 2, but varies between 1 and 4.

We shall hope also to show further on that a good reason can be found for the variation in the weights of seats which is thus brought to light.

Now, it is manifest that the facts before us here are of a kind with which builders are very familiar. For example, every carriage-builder knows that every additional seat he puts in a carriage will add to the weight of the carriage. The

addition to the weight will not be the same in all cases, but some addition to the weight there must be.

The inactive atom which goes well enough itself, though it can carry nothing on it for want of seats, corresponds to the frame and wheels of a carriage, which will not carry any one unless a seat or body of some kind is provided, though running quite well without any seat or body.

Let us turn now to the second series which the Periodic System shows.

We find on doing so that, whereas the first series was a Metal series, the second is a Metalloid or non-metal series, which runs thus :—

The first member, fluorine, weighs in round numbers 19, and takes on 1 atom in molecule building in the case of binary compounds.

The second member, oxygen, weighs 16, and takes 2 atoms; the third, nitrogen, weighs 14, and takes 3 atoms; the fourth, carbon, weighs 12, and takes on 4 atoms.

We see at once that this series, though agreeing exactly with the first series in constitution, differs markedly from that series in arrangement, inasmuch as the members, when arranged according to their weights, run in exactly the opposite order to that in which the members of the first series run. For the first member in this series has the highest weight, whereas in the first series the first member

had the lowest weight. Again, the last member in this series has the lowest weight, while in the first series the last member had the highest weight. At the same time this series affords internal evidence in regard to its origin of the same kind, precisely as the first series furnished. But we see at once that, whereas the evidence in the case of the first series shows that it was derived from an inactive element, with atoms weighing 5 incapable of taking on other atoms for want of seats, by a process of building up seats, a separate seat being provided for each atom taken on; we have now, in the case of the second series, evidence that it has been derived from an inactive element, with atoms weighing about 20, by forming seats by a process of cutting down the atom. We have seats formed as before, but formed by a process of cutting down instead of being formed by a process of building up. Let us begin with the fourth member, carbon, with atoms which weigh 12 and take on 4 atoms. On comparing its atom, weighing 12 and taking on 4 atoms, with that of the third member, nitrogen, weighing 14 and taking on 3 atoms, we see that the carbon atom gained its ability to take on an additional atom by a loss of weight amounting to 2.

On comparing the carbon atom with the atom of the second member, oxygen, weighing 16 and taking on two atoms, we see that the carbon atom gained its ability to take on two more atoms than

the oxygen atom can take by a loss in weight amounting to 4. But we have seen that one of the two additional atoms thus gained caused the carbon atom a loss in weight of 2, therefore we conclude that the gain of the other also caused it a loss of 2.

On comparing the carbon atom again with the atoms of the first member, fluorine, which weighs 19 and takes on 1 atom only, we see that the carbon atom gained its ability to take on 3 more atoms than the fluorine atom takes by suffering a loss of 7 in its weight. But we have seen that 2 out of these 3 atoms were gained at a loss of 2 in weight in each case, or at a total loss of 4, hence we conclude that the third atom was gained at a loss of 3 in weight.

Since we have thus, in the case of 3 out of the 4 atoms which the carbon atom takes on, evidence that seats were made for each of these atoms by a process of cutting down, which entailed a loss in weight of between 2 and 3 for each seat, we conclude that the fourth seat also was made in the same way as the other three, by cutting down an atom which originally had no seat and could take on no atom until a seat was made, and also that the first seat was made by removing a portion weighing about 2 from an atom weighing intact about 21.

Taking now, in the same way, the atom of the third member, nitrogen, which weighs 14 and takes

on 3 atoms, and comparing it successively with the atom of the second member, oxygen, weighing 16 and taking on 2 atoms, and with the atom of the first member, fluorine, weighing 19 and taking on 1 atom, we find that the nitrogen atom has 3 seats, and that its third seat was made by cutting down the atom, and thus removing a portion weighing 2 from an atom weighing 16 and taking 2 atoms; its second seat was made by removing a portion weighing 3 from an atom weighing 19 and taking 1 atom; and we conclude that its first seat was made by removing a portion weighing about 2 from an atom without any seat weighing intact 21.

Taking in the same way the oxygen atom which weighs 16 and takes on 2 atoms, we find that a seat for its second atom was made by removing a portion weighing 3 from an atom weighing 19 and taking 1 atom, and we conclude that a seat was also made for its first atom by removing a portion weighing about 2 from an atom without any seat weighing 21.

In the case of the fluorine atom, weighing 19 and taking 1 atom only, we conclude from the cases of the other members of its series that the one atom it takes on has a seat which was made by removing a portion weighing about 2 from an atom without any seat weighing about 21. Hence we find that all the members of the second series

which the Periodic System exhibits have been derived from an inactive element with atoms weighing about 21 by cutting down the atoms of the inactive element which can take on no atom in combination, and thereby forming seats upon them on which other atoms can be taken on, a separate seat or bed being provided for each atom taken on, and a separate portion weighing about 2 being removed in the formation of each seat or bed.

But we have in Dr. Ramsay's discovery of Neon an inactive element with atoms weighing about 20, as shown in the paper on "Argon and its Companions," by Prof. W. Ramsay and Dr. Morris Travers, which was read before the Royal Society, 15th November 1900. And we conclude, therefore, that in neon we have the origin of the second series—the raw material, in fact, out of which the four metalloïd elements in the first Metalloïd series were prepared.

It will be remembered that we have already at page 38 pointed out that the facts in connection with the preparation of the atoms of the elements in the first Metal series were of a kind with which builders are familiar. We may notice now that the facts which have just come before us in connection with the preparation of the second series are also of a kind with which builders are very familiar. For builders are in the habit of making beds or

joints by facing their materials or otherwise cutting them down so as to make a perfect fit or fine joints, and undressed blocks of stone are of no use for fine work until they are dressed. In the process of dressing, a rough block will have to be cut down and lose weight, and a separate loss of weight will occur in connection with each bed or joint for which the stone is dressed.

Looking, then, at the atoms of the Metalloid elements in the second series as materials for building molecules, we find the facts before us in the Periodic System are in complete agreement with the view that these atoms have been dressed for building purposes after the same manner as rough blocks of stone are dressed when fine masonry is being built.

And seeing that in molecule building we have, as shown by chemistry, work most accurately and regularly done, we see that the facts fit the case exactly.

We must just notice before going on that with neon as the inactive element from which the atoms of the second series were prepared, it follows, since the neon atom weighs 20, that the weight removed in forming the fluorine atom, weighing 19 and having one seat, was 1 and not 2, as shown above, and that a similar correction has to be made in connection with the formation of the first seat on each of the other atoms.

If now we pass on to the third series which the Periodic System exhibits we find that it is a Metal series, and runs thus:—

The first member, sodium, has atoms weighing each 23, and taking on 1 atom only in molecule building for binary compounds; the second member, magnesium, has atoms weighing each 24, and taking on 2 atoms; the third member, aluminium, has atoms weighing each 27, and taking on 3 atoms; the fourth member, which should have atoms weighing about 29 and taking 4 atoms, is not at present known, possibly because it is so irregular in form that its atoms cannot be disentangled from other atoms.

This being the series we can see at once that it corresponds almost exactly to the first series except in being prepared from the neon atom, weighing 20, instead of being prepared from the helium atom, weighing 4, as the first series was, according to our conclusions.

The weights of the seats differ a little; in the case of the beryllium atom in the first series the weight of the first seat put on was 3 and that of the second 2; in the case of the corresponding magnesium atom in the third series the weight of the first seat put on was 3 and that of the second 1; and in the case of the boron atom in the first series the weight of the first seat put on was 3, that of the second 2, and that of the third

2; while in the case of the corresponding aluminium atom in the third series the weight of the first seat was 3, that of the second 1, and that of the third 3.

In other respects the two series agree exactly. Thus we see that the third series is merely a reproduction of the first, with a heavier atom and some difference in the weights of the seats put on. Taking Sir William Crookes' view that all the elements have been made from one and the same primitive substance, protyle, we see that we have before us here in the third series simply the reproduction of the first series on a larger scale. We have, in fact, a case of working to pattern.

But we have more than that, for we have a Metalloid series, namely, the second series, and also a Metal series, namely, the third series, both derived from the Neon atom, and thus having a common origin. Moreover, we see that the weight of a portion put on to form a raised seat on an atom in the Metal series, namely, the third series, varies between 1 and 3, and that the weight of the portion removed to form the atom of a member of the Metalloid series also varies between 1 and 3.

If, then, we again take Sir William Crookes' view that all atoms are made of one and the same material, protyle, it would appear that the portions removed from the atoms of the Metalloid series

in cutting down seats upon them were utilised in making up raised seats on the atoms in the Metal series.

We shall see further on that we have the same arrangement recurring in the case of three other Metal series, each of which is a reproduction of the first series on a larger scale, except that some of the series have four members and not three only, as the first and third series have, and each of which also has a common origin with a Metalloid series which is a reproduction of the second series on a larger scale.

We have thus, from a builder's point of view, four reproductions of the first Metal series, and three reproductions of the first Metalloid series, and therefore manifestly a case of working to pattern; and manifestly also, from a builder's point of view, it is a most significant fact that each of the four Metalloid series, with seats formed by cutting down atoms which have no seats, should have a corresponding Metal series attached to it, with the same number of seats built up upon its atoms, and that the weight of material used in the built-up seats should correspond generally to the weight of material removed from the seats which were cut down.

This is, in fact, just what an economical builder does. A careful engineer endeavours to arrange so that the spoil from his cuttings will provide material for his banks, and thus the necessity of taking up

extra land for depositing spoil from cuttings, or for borrow-pits for providing material for his banks, may be avoided ; and the careful smith and carpenter work up the spare material from one job as far as possible in other jobs.

Hence, from a builder's point of view, we have in the Periodic System the clearest evidence that economical considerations have been attended to in the fact that the four Metalloid series are all reproductions nearly complete of the first series, and in the fact that the many Metal series, or parts of series, are most, if not all of them, reproductions complete or incomplete of the first Metal series completed by having the fourth or missing member added on to it. For the builder knows well that reproduction of this kind, which he calls working to plan or pattern, is eminently an economical arrangement, since it saves both the extra labour and expense which are entailed in getting out a number of separate designs, and in the preparation or provision of special fittings and materials for a number of dissimilar buildings. The fact that material removed from Metalloid atoms in cutting down seats was apparently turned to account to build the raised seats required for Metal atoms, tends also to show that economical considerations were not lost sight of in the preparation of atoms for molecule building.

The chemist calls the reproduction or repetition of these series over and over again Periodicity, and

calls his list of elements arranged according to these series the Periodic System. The manufacturer, too, has his series, and repeats or reproduces these series over and over again.

Take, for example, the case of flat bar iron. This, we find, is generally made in the following thicknesses in inches: $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, 1 inch, and so on. Thus we have a regular series of thicknesses in flat bar iron.

Then we find this series repeated over and over again in different widths. Thus we have the series in whole or in part in bars, 1 inch, 2 inches, 3 inches wide, and so on, as well as in many smaller or intermediate widths.

Hence a manufacturer's lists show series repeated over and over again, just as the Periodic System shows series repeated over and over again. The manufacturer's lists of materials, however, differ from the list of elements set forth in the Periodic System by chemistry, because the manufacturer shows his materials in the order of their sizes, while chemistry shows the elements in the Periodic System in the order of the weights of their atoms, or of their atomic weights, as chemistry puts it.

But since any engineering note-book will show us the weight of flat bar iron in 1-foot lengths, we can exhibit the manufacturer's materials in order of weight, instead of showing them in order of size as he does, and thus we can make the manufacturer's

series more nearly comparable with the series in the Periodic System.

Taking, then, a series of bars 1 foot long with thicknesses as shown above, namely $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$ of an inch, and so on, we find that with a width of 1 inch a bar $\frac{1}{8}$ inch thick weighs in round numbers $6\frac{1}{2}$ ounces, a bar $\frac{3}{16}$ inch thick weighs 10 ounces, a bar $\frac{1}{4}$ inch thick, $13\frac{1}{2}$ ounces, a bar $\frac{5}{16}$, 17 ounces, and so on.

Thus we have a series which stated by weight runs thus: 6.5, 10, 13.5, 17, &c.

With bars 2 inches in width the same series runs thus: 13, 20, 27, 34, &c.

With bars of 3 inches in width the series runs thus: 19.5, 30, 40.5, 51, &c.

We have now a number of Metal series which correspond in form with the Metal series of the Periodic System, leaving valency out of consideration. If we put the first Metal series of the Periodic System side by side with the first of the manufacturer's Metal series shown above, the correspondence becomes plain, as will be seen below, thus:

Metal Series, Periodic System	.	7,	9,	11
„ Manufacturer's	.	6.5,	10,	13.5

We have pointed out that the series correspond if valency is left out of consideration; but since valency means in effect value for molecule building, and thus connects the Metal series of the Periodic System directly with building purposes, it manifestly will show, if it can be taken into

consideration, the aptness of the comparison we have instituted as well as its exactness.

Let us therefore now suppose that the manufacturer, instead of making a number of flat bars of different width and thickness, makes three bars all of the same size, namely 1 inch wide, $\frac{3}{16}$ inch thick, and 6 inches long. Then, since a flat bar 12 inches long, 1 inch wide, and $\frac{3}{16}$ inch thick weighs, as shown above, 10 ounces, it follows that the three bars would each weigh 5 ounces. And now suppose that on to one of these three bars he fixes a hook weighing 2 ounces, in order to enable the bar to lay hold of a bar with a similar hook; and on to another bar two similar hooks, weighing each 2 ounces, to enable it to lay hold of two bars each, having one hook; and let us suppose that on to the last of the three bars he fixes three hooks weighing each 2 ounces, to enable it to lay hold of three bars, each having one hook. Then the first bar taking one other bar would weigh 7; the second bar taking two other bars would weigh 9, the third bar taking three other bars would weigh 11.

There would then be a series with three members weighing respectively 7, 9, and 11, corresponding both in weight and in valency to the first Metal series of the Periodic System, which has, as shown at page 34, three members, the first of which weighs 7 and takes on one atom; the second takes on two

atoms and weighs 9; and the third takes on three atoms and weighs 11.

Thus we have now a much closer correspondence between the manufacturer's series and the Metal series of the Periodic System, and, moreover, a correspondence which extends generally to all the Metal series in the Periodic System, since, as shown at page 48, all are reproductions of the first series, either in its present form or in an extended form reached by adding a fourth member taking on four atoms and weighing 13.

But we have done more than this. For we have not only arrived at a manufactured series which corresponds with the Metal series of the Periodic System, but we have arrived at this by realising the chemist's idea of the atom, as set forth by Professor Roscoe (now Sir Henry Roscoe) when he said; "Singularly enough, we have even come back again to the old notion of certain claws or points of attachment by which the atoms are fixed together,"¹ and also by Professor Nernst in the remark already given at page 2, in which he points out that when we speak of the linking of the atoms in a molecule we employ the "crude notion of a Borelli or a Lemery, who regarded the tendency of the atoms to unite firmly with each other as being due to their hook-shaped structure."²

¹ "Science Lectures for the People," 6th series, 1874, p. 25.

² "Theoretical Chemistry," translated by C. S. Palmer, p. 353.

It is clear, therefore, that in our conception of the atom we have so far been keeping within the bounds of chemical thought, and that we are making no rash or wild attempt in trying to find a form for the atom which will show it to be a manufactured article. In fact, it is perfectly plain from our series that if the Periodic System consisted entirely of Metal series we should in our hooked bars already have a form which gives us all we want. Since a flat bar weighing 4 without any hooks would give us a model of the atom of the inactive element helium, which weighs 4 and takes on no atom; the addition of one hook weighing 3 would give us the lithium atom weighing 7 and taking on one atom; the addition of a second hook weighing 2 would give the beryllium atom weighing 9 and taking on two atoms; and the addition of a third hook weighing 2 would give us the boron atom weighing 11 and taking on three atoms: thus we should have the first Metal series modelled. And since the other series are reproductions of the first series, differing mainly by having heavier atoms, we could, by taking heavier bars, thus obtain models to show all the Metal series.

So far, then, as the Metal series are concerned, the hooked bar would give a form for the atom which would explain the connection between valency and weight which the Periodic System brings out.

In the Periodic System, however, there are Metalloid series as well as Metal series, and the Metalloid series run, as shown at page 39, in exactly the opposite way to that in which the Metal series run, inasmuch as the metalloid atoms lose weight with each atom taken on by them in molecule building instead of gaining weight as the metal atoms do.

Instead, therefore, of anything in the shape of a hook or claw being added for each atom taken on, something is taken off for each atom taken on in the case of the metalloid atom.

We might, indeed, meet this difficulty by supposing that in the metalloid atom a hole is made in the bar for each atom taken on, and that the hooks on metal atoms fit into the holes in the metalloid atoms but for the fact that metalloid atoms of different kinds unite with each other to form molecules besides uniting with metal atoms. If union is effected by hooks, metalloid atoms with holes only plainly cannot unite.

It is therefore clear that no form of hooks and holes will meet the requirements of the case. And yet it is quite clear that valency requires that there should be limitations in the places of attachment by showing, as we have seen, that there are atoms, both metal and metalloid, which take on one atom only, and therefore atoms which have only one place at which other atoms can be taken on, such that when this place is occupied by an atom no

other atoms can be taken on normally; and again that there are other atoms which cannot take more than two other atoms each, and therefore cannot have more than two places at which atoms can be taken on, and so on.

It is therefore clear that a purely flat-sided form will not answer, since it could take on other atoms at any of its faces, and though we might get in a tetrahedron an atom able to take on four atoms only, we could not get an atom able to take on one atom only with a flat-faced figure.

The case being so it becomes plain that the only possible form which can meet the requirements of the case is a spherical or otherwise rounded form on which no atom can come to rest until the perfectly spherical or rounded form has been altered by having flat places or seats formed upon its surface. By making each flat place just large enough to accommodate one atom and one only the number of flat places upon the atom will indicate the number of atoms which can be taken on. A rounded form with one flat place will take on one other atom and one only; one with two flat places cannot take on more than two, and so on. And since on rounded surfaces flat places can be made in two ways, namely, by taking slices off or cutting down the surface so as to make depressed flat places; or by building up the surface so as to make elevated flat places; it is plain that we have now got a shape which will

yield forms both for metal and metalloid atoms and also the form of the atoms of inactive elements which can take on no atom.

The form which we thus obtain is for atoms of inactive elements a form rounded all over, and thus a spherical or oval or other rounded form on which no atom can come to rest but at once rolls or slips off because there is no flat place on its surface on which an atom can sit.

Out of these perfectly spherical or oval atoms belonging to the inactive elements metal atoms can be formed by building up flat places upon them in the shape of flat-topped prominences or excrescences, so that an atom which takes on one atom has one flat place so built up, an atom which takes on two other atoms has two flat places, and so on. And since the process of building up flat places necessarily adds to the weight of the atom, it is plain that each additional flat place will cause an addition to the weight of the atom, so that an atom with two flat places will weigh more than a similar atom with one flat place; an atom with three flat places will weigh more than an atom with two and so on, exactly as is the case with the atoms in the Metal series. By taking the inactive element Neon, referred to at page 43, to have perfectly spherical atoms weighing each 20, we can plainly get from it the Metal series which forms the third series of the Periodic System, referred to at page 45. Thus by building up one flat place,

which adds 3 to its weight and enables it to take on one atom, we get the sodium atom weighing 23, and taking on one atom; by building up two flat places which together add 4 to its weight, and enable it to take on two atoms, we get the magnesium atom weighing 24 and taking on two atoms; by building up three flat places, which together add 7 to its weight and enable it to take on three atoms, we get the aluminium atom weighing 27 and taking on three atoms. Thus we get the series exactly as it stands in the Periodic System. On the other hand, by cutting down these spherical or oval atoms so as to form depressed flat places upon them instead of elevated flat places the same atoms can be turned into metalloid atoms, each having one flat place for each atom it takes on; and such that an atom with two flat places will weigh less than a similar atom which has one flat place only, and an atom with three will weigh less than an atom with two flat places, and again an atom with four flat places will weigh less than an atom with three, exactly, in fact, as is the case amongst atoms in a Metalloid series as shown at page 22.

And if now we take as before the inactive element Neon to have perfectly spherical or oval atoms, each weighing 20, we can get from it the Metalloid series which forms the second series in the Periodic System.

Thus by taking one slice weighing 1 off a Neon atom so as to make one flat place upon it we reduce

its weight to 19 and get the fluorine atom weighing 19 and taking on one atom; by taking off two slices together weighing 4, and thus making two flat places on its surface, we get the oxygen atom weighing 16 and taking on two atoms; by taking off three slices which together weigh 6, and thus making three flat places on its surface and reducing its weight to 14, we get the nitrogen atom weighing 14 and taking on three atoms; lastly, by taking four slices off it together weighing 8, and thereby making four flat places on its surface and reducing its weight to 12, we get the carbon atom weighing 12 and taking on four atoms. Thus we get the second series as it stands in the Periodic System.

Now, in the paper on "Argon and its Companions," by William Ramsay, F.R.S., and Morris W. Travers, D.Sc., which was read before the Royal Society on the 15th November 1900, we find that in the case of Helium, Neon, Argon, Krypton, and Xenon "the ratio between their specific heats at constant pressure and constant volume is 1.66."¹

And in the case of Argon we find that at the discussion which followed the reading of the paper by Lord Rayleigh and Professor Ramsay in which the discovery of Argon was announced on the 31st January 1895, the following remarks were made by Principal Rücker: "It must be accepted as certain that the element has that particular ratio

¹ *Chemical News*, vol. lxxxii, p. 258.

METAL SERIES



SODIUM

One or Monovalent ; weight 23.



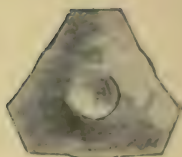
MAGNESIUM

Two or Divalent ; weight 24.



ALUMINIUM

Three or Trivalent ; weight 27.



NOT ISOLATED AS YET

Four or Tetravalent ; weight 28.

INACTIVE



NEON

Nonvalent ; weight 20.

METALLOID SERIES



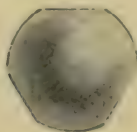
FLUORINE

One or Monovalent ; weight 19.



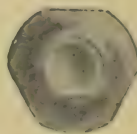
OXYGEN

Two or Divalent ; weight 16.



NITROGEN

Three or Trivalent ; weight 14.



CARBON

Asymmetrical Four or Tetravalent ; weight 12.

DIAGRAM I.

INACTIVE NEON ATOM MAGNIFIED A BILLION TIMES OR MORE,

SHOWING

THE TWO SERIES OF METAL AND METALLOID ELEMENTS DERIVED FROM IT.

of specific heats. Well, then, the question arises, What follows from this? I think that it has not perhaps been quite sufficiently pointed out, that in order that this ratio may be obtained, if we are to use the ordinary mechanical theory of gases, it is necessary that the atom with which we are dealing should be regarded as spherical."¹

Since the ratio is as we have seen above the same for Neon as for Argon, we have therefore got the form of the Neon atom fixed for us.

We are, in fact, shown Neon as having perfectly spherical atoms.

We have already arrived at general forms for the seats both of metal and metalloid atoms, and also at the number of seats on the atoms of each of the metals and metalloids in Neon's family.

We can thus assign, as shown in the accompanying illustration, a proper form to the atom of each of the metals and metalloids in Neon's family.

It will be noticed that in our illustration Neon comes between a series of metalloids headed by the halogen fluorine and a series of metals headed by the alkali metal sodium, and thus between a halogen and an alkali metal. Now, in the Eighth Annual Report of the American Committee on Atomic Weights, we find the following remark, viz.,—"The density of krypton has been carefully determined by Ladenburg and Krügel. . . . From

¹ *Chemical News*, vol. lxxi. p. 62.

it the atomic weight of the element becomes . . . 58.74 in the average. Ramsay and Travers (*Chemical News*, lxxxii. page 257) give . . . atomic weights for the new gases of the atmosphere as follows :—

	Atomic Weight.
Helium	3.96
Neon	19.94
Argon	39.96
Krypton	81.76
Xenon	128.00

“ . . . Why the value for krypton should diverge so widely from that found by Ladenburg and Krügel, is unexplained. It will be noticed that most of these gases fall between the halogens and the alkali metals in the periodic system, although argon is still slightly divergent from theory.”¹

This plainly brings out the fact that the inactive elements generally occupy in the Periodic System positions similar to that which we have found for Neon, namely, a position between the halogen fluorine and the alkali metal sodium.

The real importance of the remark made by the American Committee that the inactive elements fall between the halogens and alkali metals lies, according to our view, in the fact that these positions between the halogens and the alkali metals are no ordinary positions, but are in reality the strong positions—the keys—of the Periodic System.

¹ *Chemical News*, vol. lxxxiii. p. 162.

In fact, these positions, four in number, are strategic points in a campaign against ignorance.

They are extensions of the very positions which we ourselves ventured in "Force as an Entity," page 64, to seize and occupy temporarily with ideal inactive atoms as the result of a reconnaissance from the direction of the halogens and the four metalloid series which are headed by them, some years before any real inactive elements were known.

The weights of the ideal inactive atoms which we employed for the occupation of these positions in "Force as an Entity" were respectively 20, 40, 80, and 120. The weights of the atoms of the four real inactive elements, namely, Neon, Argon, Krypton, and Xenon, now occupying the same positions, are given by Professor Ramsay and Dr. Morris Travers in round numbers as 20, 40, 82, and 128.¹

It is reassuring intelligence to us to learn that these positions are now permanently occupied. Indeed, we are convinced that if Professor Ramsay succeeds in keeping these positions our ultimate success is assured.

We have got with them not merely one Spion Kop, but no less than four Spion Kops in our possession. And however strong may be the entrenchments of the enemy, they will not be tenable if dominated by four Spion Kops—at least that

¹ *Chemical News*, vol. lxxxii. p. 258.

TABLE showing the *Inactive Elements* side by side with the *Series of Valent Elements* to which each has given rise.

DERIVED SERIES OF METALLOIDS.				ORIGIN OF SERIES.		DERIVED SERIES OF METALS.		
	Name of Active or Valent Element.	Weight of Atom in round numbers.	Full No. of Atoms taken on in Binary Combination.	Name of Inactive Element.	Weight of Atom in round numbers.	Name of Active or Valent Element.	Weight of Atom in round numbers.	Full No. of Atoms taken on in Binary Combination.
1	...	...	...	Helium . . .	4	Lithium . . .	7	1
						Beryllium . . .	9	2
						Boron . . .	11	3
						? . . .	13	4
2	{ Fluorine . . . Oxygen . . . Nitrogen . . . Carbon . . .	{ 19 16 14 12	{ 1 2 3 4	Neon . . .	20	Sodium . . .	23	1
						Magnesium . . .	24	2
						Aluminium . . .	27	3
						? . . .	29	4

3	Chlorine	35.5	1		Potassium	39	1
	Sulphur	32	2		Calcium	40	2
	Phosphorus	31	3	40	Scandium	44	3
	Silicon	28	4	? 37	Titanium	48	4
4	...	...	...		Copper	63	1
					Zinc	65.5	2
				59	Gallium	70	3
					Germanium	72	4
5	Bromine	80	1		Rubidium	85.5	1
	Selenium	79	2		Strontium	87.5	2
	Arsenic	75	3	82	Yttrium	89	3
	?	74	4		Zirconium	91	4
6	Iodine	127	1		Cæsium	133	1
	Tellurium	125	2		Barium	137	2
	Antimony	120	3	128	Lanthanum	138.5	3
					Cerium	140	4

is our firmest belief. The accompanying table shows the four strong positions to which we have alluded, each in the occupation of one of the inactive elements in Professor Ramsay's and Dr. Morris Travers' list.

Keeping in mind the facts in regard to atoms and molecules and in regard to the nature of the series in the Periodic System pointed out in Chapter II., a glance at this table will show how each of these inactive elements has given rise on the one hand to a series of metals, and on the other hand to a similar series of metalloids. With these strong positions occupied by inactive elements with perfectly spherical atoms we are, as we believe, able to show not only the nature of the manufacturing operations by which inactive elements were converted into active or valent elements, but also the result, at all events, approximately in the form of the atom out-turned by these operations, both in the case of the metal and of the metalloid atoms.

It will be noticed that our table shows Argon, Krypton, and Xenon each with a family of metals and metalloids similar to Neon's family. These families are in fact simply reproductions of Neon's family on a larger scale. Indeed, Neon's family would be an exact representation of each of them but for the fact that Krypton's and Xenon's families have no metalloid member corresponding to carbon, while

Neon's family has no metal member corresponding to titanium in Argon's family.

It will be noticed that the prominent flat place built upon the metal atom, which takes one atom only, gives, as shown in Diagram No. 1, the atom the form of a ninepin, or that of a pear with the stalk-end cut squarely across. Thus an elongated form is indicated for this atom. It will be noticed, also, that the second prominence on the metal atom, which takes two other atoms, lengthens the atom on the opposite side, and thus that a still more elongated form is indicated for this atom. It will be seen, also, that an elongated form with two projections is indicated for the metal atom, which takes three other atoms, and thus has three prominences; and, also, that an elongated form with three projections is indicated for the metal atom, which takes four other atoms.

For the metalloid atom, on the other hand, the form indicated is that of a chipped sphere, with one, two, three, or four flat places on its surface, corresponding to the number of atoms taken on.

In the case of the carbon atom, which has four flat places, the conclusions of stereochemistry show that these flat places are not symmetrically disposed round the atom, so as to have all their centres in the same plane, but are unsymmetrically arranged at the angles of a tetrahedron.

The elongated form thus indicated for the metal

atom, with projections in the cases of atoms which take on three or four other atoms, may give us an explanation of the fact, that the metals generally are characterised by ductility, which enables them to be drawn out into wires; by malleability, which enables them to be beaten or rolled out into sheets; and at the same time, by a want of volatility, as shown by the fact that none of them are gases, and most of them are vaporised with difficulty.

Our experience in spinning thread and twisting hay, or other bands, shows that an elongated form is necessary for ductility; and experience in felting or matting wool, or other materials, shows that an elongated form will explain malleability also. It is also plain that the difficulty we experience in getting things of an elongated form out of heaps in which they are entangled will show us that atoms of an elongated form would have a difficulty in freeing themselves from solid masses in which they were entangled; and, therefore, that an elongated form would explain the want of volatility in metal atoms. On the other hand, the short-docked form of the metalloid atom will explain the volatility of the metalloids, as shown by the fact that four out of the fourteen metalloids at present known are permanent gases, and all the others can be volatilised at comparatively low temperatures; since our ordinary experience tells us that things which are short and rounded in form are easily detached from heaps and scattered.

The same form manifestly explains the absence of ductility and malleability in metalloids.

The properties of the elements thus enable us in a measure to confirm the correctness of the conclusions, in regard to the form of the atom, drawn from the facts shown by the Periodic System.

The form we obtain for the atom manifestly explains the regularity and precision with which molecules are built up in the case of molecules of simple or binary compounds, and thus gives a clear explanation of the ordinary valency or power of taking on atoms of another kind shown by the elements.

But, besides this, it gives an explanation of variable valency also. For, in the case of atoms which have several flat places or craters, it is plain that if the supply of atoms of another kind is not sufficient for the occupation of all their flat places some will be left unoccupied. Thus we may have atoms with four flat places getting one only, or two only, of their flat places occupied, and, therefore, we may have, in the case of such atoms, four different kinds of valency shown, for we may have them taking one atom only, or two, or three, or four atoms.

Then, again, variable valency may plainly be occasioned by the fact, referred to at p. 27, that atoms, even when uncombined, are with a few notable exceptions, viz., the atoms of mercury and cadmium

and those of the inactive elements Helium, Neon, Argon, &c., which are monatomic, paired together and not single; and that it is necessary for these pairs of atoms, or diatomic molecules, as they are called in chemistry, to be broken up before the atoms composing them can unite with atoms of other substances to form compound molecules instead of diatomic molecules.

For it is plain, that if the flat places on an atom are widely separated, the two atoms in any pairs of atoms which are to combine with it must be more widely separated, in order that both may get seated upon it, than would be necessary if the flat places were close together. And we can even understand that the flat places may on some atoms be so far apart that it may be quite impossible to separate the atoms in some pairs of atoms sufficiently to enable the atoms in these pairs to get seated on those atoms.

We can also, if the flat places on an atom are not symmetrically disposed upon its surface, understand how it may happen, that, while two of them are close enough together to get occupants, two others may be so far apart as to remain unoccupied in the case of pairs of atoms which are with difficulty separated. At the same time, it may also happen that when this particular substance is combining with some other substance, with pairs of atoms which can easily be separated, it may get all

the flat places on its atoms occupied, although, with the other substances, it could have only a part of those flat places occupied.

In such a case the substance will show variable valency of another kind. For it will take more atoms, and thus have a higher valency when it is combining with the substance having pairs of atoms easily separated and a smaller number of atoms, and thus a lower valency with the other substances having pairs of atoms which are broken up with difficulty. We have, according to this view, a good instance of this kind of variable valency in the case of carbon, which takes four atoms, and thus is four-valent or tetra-valent with hydrogen, while taking two atoms, and thus being two-valent or di-valent only with oxygen.

If we turn to p. 58 we shall see that the carbon atom, shown in Diagram No. 1, has an unsymmetrical arrangement of its flat places, inasmuch as they are shown by stereochemistry to be disposed at the angles of a tetrahedron, and not in a ring about the middle of the atom.

This being the case, we can, if the pair of atoms in an oxygen molecule cannot be separated without much difficulty, while the pair of atoms in a hydrogen molecule can be easily separated, understand how it may be possible to get the atoms in hydrogen molecules separated sufficiently to occupy all the flat places on carbon atoms: and also how

it may be possible to separate the two atoms in an oxygen molecule sufficiently to get them seated on any two of the flat places at the base of the tetrahedron; but at the same time impossible to separate them enough for one to get seated at the apex, while the other takes one of the flat places at the base of the tetrahedron.

If the case be really so, it is clear that the carbon atom would be unable to take more than two atoms of oxygen, although it gets its full complement of four atoms when it is combining with hydrogen, with atoms which can be separated more easily.

Then, again, it is manifestly possible for abnormal valency to arise. For atoms, when seated on the flat places on another atom, may plainly have the intervals between them large enough to allow other pairs of atoms to be caught in the middle, and wedged tightly in between the atoms which are seated, so as to sit crosswise upon the central atom without having any regular seat. If there is a tight fit, it is plain that a pair of atoms may thus sit firmly without having any flat place to sit upon.

In this way an atom, which normally takes three atoms only in combining, may get five or possibly even seven atoms seated upon it, and an atom which normally takes four other atoms when combining may take five, or six, or possibly even seven, or eight

atoms. In this way we may account for the behaviour of the tungsten atom when it takes in one compound five, and in another six atoms of chlorine.

In this way, also, we may account for the behaviour of iodine, when it takes five atoms of fluorine instead of one only; except that in this case additional molecules are not wedged in between pairs of atoms, normally seated; but we have two molecules of fluorine, and thus four atoms forming a girdle round a single central atom of fluorine, which occupies the one flat place upon the iodine atom, and is thus normally seated. Four of the fluorine atoms have no seats, but holding on to each other, and being kept in position by the single fluorine atom, which has a seat, ride safely on the iodine atom.

We have thus obtained a form for the atom, which accounts for the extreme precision and regularity with which simple molecules are built up out of the atoms of two substances.

But we know from chemistry that extremely complex molecules, consisting in some cases of hundreds of atoms, are built up with the same regularity and precision as is noticeable in the case of simple molecules. And we can easily account for this also with the form we have obtained.

For, on turning to p. 58, we see that the oxygen atom has two flat places. When then oxygen combines with some other substance, such, for

example, as carbon, to form simple molecules of carbonic acid, or carbon dioxide, two of its atoms are resting, each on one of its flat places, on a flat place on the carbon atom; at the same time each of them has one flat place unoccupied, and available to take on an atom of any other kind, or any molecule which has an unoccupied flat place. If an atom is taken on, the simple molecule of carbonic acid or carbon dioxide will be converted into a complex molecule. The complex molecule so formed will still have an oxygen atom with one flat place unoccupied, and thus may take on a complex molecule.

The simple molecule of carbon dioxide, which was first formed by the combination of atoms of two kinds, may thus be converted into a complex molecule, in which complex molecules are combined together. These complex molecules, if they have any flat place unoccupied, or easily rendered vacant by having one of their atoms knocked off, may each take on another molecule as complex as itself. Thus there may be a continual growth in complexity.

But since, in all cases, additional atoms or molecules can only be taken on by a molecule at its unoccupied flat places, and since also all molecules of the same kind are built up in the same way, and, therefore, have their unoccupied flat places in the same positions, it is plain that there will be the

same precision and regularity in the building up of complex molecules as in the building up of simple molecules.

It may be well to notice how readily, according to this view, the carbonic acid or carbon dioxide molecule lends itself to the formation of complex molecules.

In the first place, it has two unoccupied seats on the carbon atom; for it takes, as we have seen at p. 69, two oxygen atoms only, but has, as shown at p. 65, four seats, and thus has two only of its seats occupied; and then the two oxygen atoms, which it takes on, have each, as we have just seen, an unoccupied seat. Hence it has four unoccupied seats, each of which is available for taking on another atom or molecule. The fact that it is a permanent gas should, of course, add immensely to its activity.

It is, therefore, not surprising to find that the carbonic acid or carbon dioxide molecule is the basis of life, inasmuch as vegetable life uses the carbon dioxide molecule in all its structures along with the water molecule, which, however, has no unoccupied flat places, and must have one or both of its hydrogen atoms stripped off it before it can be used in building up complex molecules.

The carbon disulphide molecule should have, indeed, the same number of unoccupied seats as the carbon dioxide molecule has. But carbon disulphide

is a liquid and not a gas, and this fact perhaps explains why it has little of the activity which the carbon dioxide molecule has.

The silicon dioxide or silicic acid molecule should also have the same number of flat places as the carbon dioxide molecule, but then silicon dioxide is a solid, and therefore very inert.

The fact that at ordinary temperatures on our earth's surface silicic acid or silicon dioxide is a solid and therefore inert, while carbonic acid or carbon dioxide is a gas and therefore active, throws light upon a remark made by Professor Bunge to which we shall have occasion to refer later on. "Silicic acid and carbonic acid," says Professor Bunge, "are 'the two great powers in the construction of the earth,' and are always at war with each other, with alternate victory and defeat on each side . . . the carbonic is the more powerful acid on the earth's surface . . . and slowly but surely destroys the hardest rock; the carbonic acid unites with the basic constituents, and the displaced silicic acid, combined with the residue of the bases, sinks to the bottom of the water, where, as clay or sandstone, it gradually forms massive strata of the earth's surface."

“But the struggle between the two acids wears another aspect in the interior of the earth. At the higher temperature which prevails there, the silicic

acid is the more powerful. In the depths of the earth it attacks the carbonates, and the carbonic acid, which is driven off, escapes into the atmosphere."¹

We can readily understand how in the cold the active permanent carbonic acid gas prevails over the inert solid silicic acid and displaces it. And we can also readily understand how at a high temperature the heavy silicic acid molecules, roused to activity by the heat, are able to overcome and displace the light molecules of carbonic acid.

We can now perhaps see how it may be possible for a complex molecule, built upon a carbon dioxide molecule, by two other molecules being taken on to the two unoccupied seats on the carbon atom, to have a dextro or lævo arrangement of its molecules. For if one of the seats in question is at the apex and the other at one of the angles at the base of the tetrahedron, about which the seats in a carbon atom are arranged, as shown at p. 69, the molecule at the base, as will be seen from Diagram No. 1, will usually be either to the right or to the left of the molecule at the apex. A beam of light, passing by the molecule at the apex to the molecule at the base, may, therefore, be rotated either to the left or to the right.

We have thus obtained a form for the atom

¹ "Physiological and Pathological Chemistry," translated by Wooldridge, p. 17.

which, as we believe, explains the formation of molecules, and the precision and regularity with which, as chemistry finds, they are built. This form explains the formation not only of simple molecules, but also the formation of complex molecules out of simple molecules; and explains also how complex molecules are converted into others still more complex; and shows how all are put together with perfect regularity and precision, whether they are simple molecules, or molecules exceedingly complex.

The form thus obtained for the atom gives us most plainly the foundation of an inorganic Evolution, since it gives the evolution of the molecule, and shows how the most complex molecules are evolved, or gradually built up out of simple atoms. But Science shows that masses are, in some cases, built up with regularity and precision as well as molecules. It points to the regularity with which crystals are built up, and shows that though some substances crystallise in several different forms, still each of these forms may have the faces of its crystals inclined at the same angle as the others have, and thus a constant angle of inclination for the faces of its crystals: and thus shows that masses as well as molecules are built so far with precision and regularity.

If we ask ourselves whether there are any facts in molar physics which can explain the precision and regularity with which, in this respect,

crystalline masses are built up, we shall find, if we look at a crystalline mass as a regular pile of molecules, that there are facts in connection with the piling up of bodies which throw light upon the matter.

If we pay a visit to an arsenal, and examine the

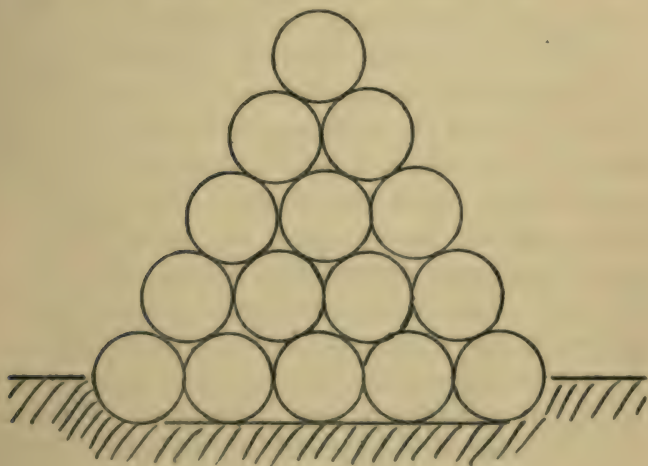


FIG. 2.—TRIANGULAR PILE OF ROUND SHOT

piles of shot which it contains, we shall find that they are built with precision and regularity in certain ways. If we can find any piles of round shot or shell still remaining, we shall find that they are of three forms, namely, the prism or pile with rectangular base, the pyramid or pile with square base, and the tetrahedron or pile with triangular

base, and we shall find that all piles built of shot of the same description have the same angle of inclination between the bases and the sides and ends of their piles. But the point which specially deserves notice is the fact that these piles have crystalline forms, or parts of such forms. Thus the pyramid with a square base is half of an octahedron, a pile with a rectangular base is half of a prism.

If we examine these piles we shall find that the shot remain in the piles, because each has, as shown in Fig. 2, a seat for itself, in the shape of a depression in the ground, or a place inside a band, or ring of some kind, in the case of the bottom layer, and in the intervals between other shot below it in the case of the upper layers. The portion of the shot which is down in the depression, either in the ground or in the intervals between the shot below it, catches against the sides of the depression or band, &c., and thus is held in position. We see, therefore, that it is impossible to build piles with vertical faces with round shot, and we see also that in piles built with round shot the angle between the base and each of the faces is constant, provided that the shot are perfectly spherical in form, and those in the bottom layer are laid close together; though, of course, in practice, there is some deviation, on account of irregularity of form and irregularity in stacking. But now, if we turn to the elongated modern projectiles, we see that with them

it is possible to build piles with vertical faces. Thus we see that piles of round shot of necessity take certain forms, and piles of elongated shot take other forms. And we conclude that molecules of the same form as shot will, if piled together to form masses, take the same forms as piles of shot take, and conclude also that in piles of shot we have an explanation of the way crystals are formed with the regularity and precision which we find in nature. But the piles of shot explain to us also the formation of masses generally, as well as the formation of crystals, for they show that all that is necessary for the formation of masses out of molecules of the forms we have obtained is to bring the molecules so close together, that parts of them may get interlocked or entangled with each other.

The substance which binds the atoms and keeps them in their places in a molecule will plainly serve to keep molecules in their places in a mass when they are interlocked or entangled with each other.

It is easy with this view of cohesion, which connects it with the interlocking of solid atoms, to see why masses should become solid when they are condensed or contracted. But it is not easy to see at once how it is possible for masses to expand on solidifying, as is the case with water. However, questions such as these enable us to test the validity of our conclusions, and find out whether there is anything in them. It may be worth while, therefore,

to see whether our conclusions will help us to understand the behaviour of water in expanding when it freezes, and, in fact, before it freezes.

We must begin by asking another question, namely the question—why is water, which has molecules composed of two atoms of hydrogen and one of oxygen, a liquid and not a gas? Oxygen and hydrogen are both light gases; moreover, hydrogen sulphide, which has molecules composed of two atoms of hydrogen united to one sulphur atom, hydrogen selenide, with two atoms of hydrogen united to one atom of selenium, and hydrogen telluride, with two atoms of hydrogen united to one atom of tellurium, are all gases; while sulphur, selenium, and tellurium are all solids, the first with atoms twice, the second with atoms nearly five times, and the last with atoms nearly eight times as heavy as the oxygen atom. In view of these facts the only way, to our mind, of accounting satisfactorily for the fact that water is a liquid and not a gas is by assuming that its molecules form chains, which are not so volatile as separate molecules would be.

If water molecules form chains, then, according to our view of the shape of the atom, chains of water molecules will resemble strings of beads. And with Sir William Crookes' view, that atoms are all made of the same primitive substance, protyle, oxygen atoms, which are sixteen times as

heavy as hydrogen atoms, will be like very large beads, and hydrogen atoms will be like very small beads. Then, since water molecules consist of two hydrogen atoms united to one oxygen atom, chains of water molecules will resemble strings of beads made up of large beads with two very small beads between each of them.

Now, when the chains are very flexible and the atoms far apart, they will resemble strings of beads with wide intervals between the large beads. But strings of beads, which are all exactly alike, can manifestly be laid very close together, if the gaps between the large beads are wide enough to allow the large beads in one row to fit into the gaps formed by the small beads in the strings on all sides of it.

If, however, the atoms in the chains close up, they may resemble strings of beads with intervals between the large beads not wide enough to allow the strings to be laid so close together as before. There will then be lateral expansion along with longitudinal contraction.

If the lateral expansion exceeds in amount the longitudinal contraction, the mass on the whole will expand.

The large atoms may conceivably be gripped more tightly when the atoms close up than they were before when the gaps were wide, even though they are forced outwards.

CHAPTER IV

NEWTON'S AGENTS IN NATURE

IN the next age which science shows us we have activity, not in altering the atom, as in the first age, but in altering the positions of the atoms in space.

For science shows us, by the Kinetic Theory of Gases, as we have seen in Chapter II., the atoms, after they have been most carefully and accurately prepared for molecule building, all scattered and dispersed throughout space, by being given a wild chaotic motion which sets them flying in all directions independently of each other.

In this age we have the purpose for which the atoms were so carefully prepared in the preceding age of Creation completely lost sight of, and the object in shaping them as building materials—as materials for molecule building—completely defeated.

Science shows us that it was energy which effected the dispersion of the atoms. For it tells us that energy is "the life and activity" of the

universe, as we have seen at p. 16, and that matter is simply passive.

In the preceding chapter we were dealing with matter in the form of atoms, and thus with one of the two realities which science recognises, as we have seen at p. 15. In the Kinetic Theory of Gases we pass to the other reality which science recognises. We have found a real form for the inert unalterable atom which makes matter a reality.

If we can obtain a real form for energy, whether as a whole or as made up of parts, we shall plainly make it a reality also.

One thing is quite clear, and that is, that we require a form able to lay hold of atoms and set them in motion if we are to explain the Kinetic Theory of Gases by the activity of energy operating by a body or bodies of any real form.

Now in this connection we find that Newton has pointed out from phenomena connected with what is now called capillary action and from other phenomena that "there are therefore agents in nature able to make the particles of bodies stick together by very strong Attractions,"¹ and added that "it is the business of experimental philosophy to find them out."

If we can carry out Newton's injunction, and find out, by experiments, agents in nature able to make atoms "stick together by very strong Attractions,"

¹ "Opticks," third edition, p. 369.

and deduce a form for them, we shall plainly get real energy of one kind, namely, energy of Attraction able to draw or press atoms together.

And if in the case of energy of Attraction we can get a real form able to draw or press atoms together, it will, as we conclude, be a comparatively easy matter to get through Antagonism a form for energy of the opposite kind, able to drive atoms apart, and thus disperse them in the way the Kinetic Theory of Gases shows them to have been scattered.

If we succeed in finding Newton's agents in nature, we shall not only confirm Newton's conclusions; but we shall also have an explanation of chemical union which brings together "the crude notion of a Borelli or a Lemery, who," as Professor Nernst tells us, as shown at p. 2, regarded the tendency of the atoms to unite as "being due to their hook-shaped structure," and the "well-conceived achievements of a Newton, a Bergman, or a Berthollet, who," as Professor Nernst also pointed out, as shown at p. 2, "saw in the chemical process a phenomenon of attraction, which was comparable with the fall of a stone to the earth." We shall clear the notions of a Borelli or a Lemery of their crudeness, by replacing the hooks of their hooked atoms by seats, in the shape of flat places on the surfaces of spherical or oval atoms, on which the atoms can and will naturally come to rest of themselves, and away

from which they cannot come to rest at all. And since chemical thought in regard to "the nature of the forces which come into play in the chemical union . . . of substances," has, as Professor Nernst pointed out in a remark given on p. 2, ranged between these two notions as extremes, we shall have an explanation wide enough to cover the whole range of chemical thought in regard to the chemical union of atoms.

We shall also wipe away the reproach conveyed in Nernst's remark when, regarding our knowledge of the nature of chemical forces, he says that "not much further advance has been made, even at the present time," since the question was first agitated, "as long ago as the time of the Grecian philosophers."¹

We may remark, before proceeding further, that the Periodic System seems to show in the weight of the atom, that in preparing the atom for molecule building special provision was made for accommodating Newton's agents with real bodies able to lay hold of atoms. This is apparently shown by the fact that while the entire weight of the hydrogen atom is only 1, at the same time, in the case of metalloid atoms, the slice taken off to make a flat place or seat, which must not be large enough to accommodate more than one hydrogen atom, weighs often 2, and sometimes as much as 3. From this the conclusion seems warranted that the seat is

¹ "Theoretical Chemistry," translated by C. S. Palmer, p. 353.

not flat all over, but hollowed out in the middle, and thus a flat-lipped crater. Otherwise a seat made by taking off a slice weighing 2 would necessarily be large enough to accommodate several hydrogen atoms themselves, all monovalent, and therefore not discoidal in shape, and weighing 1: and such a thing as a monovalent atom able to take one hydrogen atom only would be an impossibility. The facts, therefore, point strongly to the conclusion that the seats on atoms are craters, which are all of one size at the lip, but vary in depth according as the weight of material removed in forming them is large or small. This will explain not only why the weight of material removed in making a crater varies a good deal in different cases, but also why some atoms are more firmly bound together in molecules than others are.

We have seen above that Newton based his conclusions in regard to the existence of "agents in nature able to cause the particles of bodies to stick together by very strong Attractions," largely upon experiments in connection with what is now called capillary action, under which fluids rise in opposition to gravity inside fine tubes and between plates of glass, &c., which are very close together, when the tubes and plates of glass are partially immersed in the fluids.

Now, in experiments of this kind, which any one and every one can try for himself or herself, it is

perfectly clear that a fluid, when it rises thus in opposition to gravity, inside a fine tube and between plates of glass which are close together, tends to pull the tube and the plates of glass down.

It is quite clear that when a man climbs up a tree in opposition to gravity, by laying hold of the branches he pulls the branches downwards, and also tends to pull the tree down through its branches. Whether, therefore, the tube and the plates of glass pull the fluid or not, it is perfectly clear that the fluid pulls the tubes and the plates. In fact, it is easy to show by experiments that the tubes and plates are pulled by the fluid. For we take a very thin and light plate of glass, such as one of the cover-slips used in microscopical work, and attach a very fine and flexible spring to it, so that the spring is at right angles to the slip; and then make the slip of glass chemically clean; we find then that if, while the spring is kept in a horizontal position, so as to be easily deflected downwards, one edge of the slip is allowed to dip into pure cold water, the spring will be sharply deflected downwards as soon as the edge of the slip touches the water.

This is manifestly the view that Newton takes when he brings forward, as we have seen he does, experiments showing the rise of water in tubes and between plates to show the existence of "agents in nature able to cause the particles of bodies to stick together by very strong Attractions," and says that

it is the duty of experimental philosophy to find out these agents. If we take the clue which Newton has thus given us, we find that there is a class of phenomena, unknown in Newton's day, which bring out most clearly the power of fluid attraction to make the particles of bodies stick together.

The phenomena in question have to do with *Water of Crystallisation*, as it is called in chemistry. We find from chemistry that many of the beautiful crystals which are known to us are built up entirely by water in the form of water of crystallisation, as is clearly shown by the fact that the crystals in many cases fall "to powder when this . . . water is driven off by heat."¹

Thus, for example, we find that the beautiful blue prismatic crystals of sulphate of copper, called by housekeepers bluestone, consist of the substance known to chemists as anhydrous sulphate of copper, and water, in the proportion of five molecules of water to one molecule of sulphate of copper.

And we find also that when these blue crystals are "heated to the boiling point of water they become opaque, and may be easily crumbled down to a nearly white powder," which consists of anhydrous sulphate of copper and water, in the proportion of one molecule of water to one molecule of sulphate of copper.

And we learn that "the four molecules of water

¹ Roscoe and Schorlemmer's "Treatise on Chemistry," Vol. i., new edition, 1888, p. 244.

which have been expelled, constituted the water of crystallisation, upon which the form and colour of the sulphate of copper depend." Also, that "the one molecule of water which still remains is not expelled until the salt is heated to 390°F ., 199°C ., proving that it is held to the sulphate of copper by a more powerful chemical attraction. On this account it is spoken of as *water of constitution*." ¹

Again, in the case of magnesium sulphate, familiarly known as "Epsom salts," which crystallises "in four-sided rhombic prisms," we learn from Professor Victor von Richter that "it crystallises with six molecules" of water "from solutions heated to 70° ," and that at 0° "it has twelve molecules."

We learn also that "when heated to 150° these hydrates lose all their water of crystallisation, excepting *one* molecule, which escapes above 200° ." ²

In reference to these results, Professor Victor von Richter remarks that, "*One* molecule of water in magnesium sulphate is therefore more closely combined than the rest. Many other salts containing water deport themselves similarly. The more intimately combined water is termed *water of constitution*." ³

In the case of ordinary alum, which is known to chemists as potassium aluminium sulphate, and "crystallises from water in large, transparent

¹ Bloxam's Chemistry, eighth edition, p. 49.

² "Inorganic Chemistry," translated by E. F. Smith, p. 317.

³ Ibid., p. 317.

octahedra," we learn that it takes twelve molecules of water to each alum molecule; also that "when heated it melts in its water of crystallisation, loses all the latter, and becomes a white voluminous mass—*burnt alum*." ¹

In reference to other cases, we learn that "most crystals containing water have their crystalline form destroyed or modified by the loss of the water." ²

And in regard to water of crystallisation we learn the important fact that it "is generally expelled at 212° F. (100° C.), and is connected with the form and colour of the crystals." ³

We thus learn that water of crystallisation goes off from crystals at about the same temperature as it boils off from our kettles, and therefore we conclude that it exists as water in the ordinary form, in the crystals which are built up by it, and fall to pieces when it goes off.

Here, then, we have water in its ordinary form exhibiting a marvellous power of binding together molecules of compound substances of many different kinds, and building with them beautiful crystalline forms with perfect regularity and order.

We hope to show now that there are experiments in molar physics which throw light upon the matter, and enable us to understand the case completely in its general aspect.

¹ "Inorganic Chemistry," translated by E. F. Smith, p. 356.

² Bloxam's Chemistry, eighth edition, p. 49.

³ Ibid., p. 49.

At the same time, we may point out that it seems to us that there are details which need to be studied much more closely than has hitherto been done. And we may point out also, that the matter is one of extraordinary importance, because of its connection with the production of living forms, as Professor Sachs has pointed out in connection with the structure of protoplasm, which forms the principal part of the structure of every living cell, both in plants and animals. "It is," says Professor Sachs, "moreover, only an abbreviation, to say that protoplasm consists of proteids. This is only its essentially distinctive character; but, as a matter of fact, living protoplasm always contains a larger or smaller quantity of water, and if this is withdrawn up to a certain minimum, it loses its vital activity, and on the withdrawal of more water, even its ability to live. The water belongs to the molecular structure of the living protoplasm in the same sense as the water of crystallisation is necessary to the structure of very many crystals, which lose their crystalline form on the withdrawal of the water of crystallisation."¹

We see, therefore, that the case is one of very far-reaching importance, and that our time will be well spent in trying to elucidate it.

The point before us is, that in water of crystallisation we have water in its ordinary form building

¹ "On the Physiology of Plants," translated by H. M. Ward, p. 79.

up with the molecules of various compounds beautiful crystals, in a perfectly regular and orderly way, and we want to find out how it is possible for water to do this.

Now we have an old and well-known experiment which throws much light upon the matter. The experiment in question is that of taking two clean plates of glass, and after bringing one almost down upon the other, so as to leave an interval not more than one-tenth of an inch in width between them, introducing a drop of water between them, with the result that the drop spreads out in a film between the two plates of glass, and forcibly draws them closer together, and afterwards binds them firmly together.

Clerk Maxwell remarks that "the force thus produced by the introduction of a drop of water between two plates is enormous, and is often sufficient to press certain parts of the plates together so powerfully as to bruise them or break them."¹

Now here we plainly have water in its ordinary form doing, on a large scale, visibly between plates of glass, by drawing the plates and binding them together, exactly what water does on an exceedingly minute scale, when in its ordinary form it takes the molecules of various compound substances, and builds up with them beautiful crystals, such, for

¹ Article, *Capillary Action*, "Encyclopædia Britannica," ninth edition, p. 65.

example, as the beautiful blue prismatic crystals which it builds with sulphate of copper molecules, as we have seen at p. 88.

Thus we have a case in molar physics, which explains to us a phenomenon of vast importance in molecular physics.

We find, however, that Professor Tait endeavoured to explain the action of a drop of water between two plates of glass by atmospheric pressure. He remarks that "when a mere drop of water is placed between two very true glass planes, the relief of pressure produced enables the atmospheric pressure to force them closer together, and this effect increases, not only by the enlargement of the wetted surfaces, but by the increase of curvature round the edges."¹

But Clerk Maxwell points out that "the plates will be pressed together . . . whether the atmosphere exerts any pressure or not."²

However, Clerk Maxwell, though recognising that the plates are pressed together irrespective of atmospheric pressure, does not apparently refer the effect to the action of the water in drawing the plates together, but to the action of the plates in attracting the water, and thus pressing themselves together.

In taking this view he does not seem to have taken into account the action of water in the form of

¹ "Properties of Matter," second edition, p. 259.

² Article, *Capillary Action*, "Encyclopædia Britannica," ninth edition.

water of crystallisation between the molecules of compounds.

But, however that may be, we are now, as we believe, in a position to settle the question finally by modifying the experiment with the plates of glass, so as to make it clear, beyond all possibility of doubt, that the plates are drawn together by the water.

For we take two very light plates of glass, such as the cover slips used in microscopic work, and, after making them chemically clean, put a drop of water upon the edge of one of them on its under side, when the plate is in a horizontal position; and then bring the other plate end on towards the wetted edge of the first plate, until the edge of the dry plate just touches the bottom of the drop of water on the wetted plate. We find then that when the plates are thus almost end on to each other the drop of water at once seizes the plate which is thus brought to it, and drags it, if free to move, under the plate to which it is itself adhering, and spreading out in a film between the plates binds them firmly together.

If both plates are free to move, the plate to which the drop is adhering will be drawn forward over the other plate at the same time as the latter is drawn under the former.

If the drop of water is placed on the upper edge of the first plate, instead of on the under edge, and

then the second plate is brought as before end on to the first, until its edge touches the top of the drop of water, the second plate will be drawn over the first instead of under it.

It will be noticed that the experiment in this form shows that a drop of water is able to take hold of the plates, even when they are almost end on to each other, and fit them together; and afterwards bind them firmly together: and thus that water is able to build up piles of plates by drawing them in, and putting them one upon another. The water visibly puts the plates into their proper positions for building piles.

The experiment, therefore, in this form shows not only that water can draw plates of glass together, but also that it can, under certain circumstances, build with them such forms as they are suited for building, provided they are light enough to be moved by it.

But water is not the only fluid that can do this, for we find that any fluid which wets glass will do it also.

We find also that other plates besides glass plates will be drawn together, provided that the fluid introduced between them is one which wets or adheres to their surfaces in the same way as water wets glass.

Hence we conclude that if atoms are solid bodies with flat places on their surfaces, and if at the same time a fluid, which is able to wet their surfaces in

the same way as water wets glass, is introduced between them, the result will be that the fluid will draw them and bind them together whenever their flat places come opposite each other, provided that they are close enough together to be drawn. In this conclusion we assume that the fluid will behave exactly in the same way as our experiment shows that a drop of water behaves when it is introduced between two plates of glass, close enough together to allow the drop to lay hold of both. We assume, therefore, nothing which is not warranted by facts.

But the form for the atom at which we have already arrived gives us solid atoms with flat places on surfaces elsewhere rounded; that is to say, it gives us spherical atoms with flat places on their surfaces.

Hence our experiment, which shows that glass plates, which are almost end on to each other, can be drawn and bound together by drops of water, shows also that atoms of the forms at which we have arrived would be drawn together, and built up with accuracy into molecules, and bound firmly together, provided that a suitable fluid were introduced between them when they were close enough together to be drawn.

But our experiment shows us more than this. For it shows us that if Space is filled with solid atoms not touching each other, but still close enough to one another to be drawn together by fluid

attraction; and if then a fluid which wets the atoms is introduced between them: the result will be that, everywhere throughout the immensity of Space, atom will be drawn to atom. Thus there will be universal gravitation amongst the atoms instantaneous in its action if unresisted, but if resisted continuing to act while the resistance remains.

We have thus arrived at a fluid explanation the sufficiency of which can be experimentally demonstrated, not only of chemical union, but also of cohesion and gravitation.

The explanation, however, is only valid provided that atoms are scattered throughout the whole of space, so as not to touch each other, and yet to be separated by very small intervals. But here comes in the remarkable fact that the Kinetic Theory of Gases shows us atoms scattered in the way required for our explanation.

It will be remembered that it has been pointed out at p. 27 that the Kinetic Theory of Gases shows us, that before the advent of Attraction, the universe had the form of an ideal gas, and was filled with atoms shaped accurately for building molecules, but not put together in molecules because they had been turned into ideal gases of the kind which the Kinetic Theory of Gases reveals, by being sent flying throughout space in all directions independently of each other.

Clerk Maxwell has given us some idea of the

average distance between the molecules of some of the well-known gases, according to the Kinetic Theory. Clerk Maxwell says, "We know already the velocity of the molecules, and therefore, by experiments on diffusion, we can determine how far, on an average, a molecule travels without striking another. Professor Clausius, of Bonn, who first gave us precise ideas about the motion of agitation of molecules, calls this distance the mean path of a molecule. I have calculated, from Professor Loschmidt's diffusion experiments, the mean path of the molecules of four well-known gases. The average distance travelled by a molecule between one collision and another is given in the table. It is a very small distance, quite imperceptible to us even with our best microscopes. Roughly speaking, it is about the tenth part of the length of a wave of light, which you know is a very small quantity."¹

It is therefore plain that the Kinetic Theory of Gases shows us a distribution of atoms of matter in space well suited for the operations of fluid attraction. We have therefore got atoms of the proper form prepared and made ready for molecule building, which is, as we have seen at page 18, the first stage in the building of our universe, as shown very clearly by chemistry. And we have got the atoms distributed throughout space in the way required for the commencement of building operations, as

¹ "Scientific Papers," edited by Niven, vol. ii. p. 369.

shown by the experiment with plates of glass. In fact, nothing is wanting now for the building of the universe but the advent of a sufficient supply of a fluid of the requisite subtlety and attractive power to get between atoms of matter and draw them together.

We conclude that the fluid required must be a form of energy, namely, attractive energy. We have seen, at page 15, that science recognises two realities only, namely, matter which is strictly passive or inert, and is the receptacle of energy, as Professor Tait pointed out, and energy which is the life and activity of the universe.

We have seen also at page 17 that there are two principal states of matter, namely, the solid and the fluid, if we include under the term fluid both the gaseous and the liquid states. But if we institute a comparison between these two principal states we perceive that the solid state is characterised by inertness, while the fluid state is characterised by activity; in fact, we have seen at page 26 that the Kinetic Theory of Gases shows that in a gas the molecules are in a state of ceaseless commotion, flying in all directions independently of each other.

Hence we conclude that in the solid state we have an excess of matter, and in the fluid state an excess of energy, and that if we could strain off all the energy from the solid and all the matter from the fluid, we should have matter shown as pure solidity and energy shown as pure fluidity.

We conclude, therefore, that energy is fluid in its nature and matter solid.

We conclude also that gravitation, chemical union, and cohesion are all forms of fluid attraction, and are due to an influx of attractive energy.

Now water, which shows us fluid attraction with such wonderful clearness when a drop of it is introduced between two clean plates of glass, and when it builds up, as we have seen, in the form of water of crystallisation, crystals of different kinds, very regularly and beautifully, is, as we know, not a continuous substance. The chemist analyses it, and thus takes it to pieces, and shows that it is made up of the two gases oxygen and hydrogen in a state of chemical combination. The chemist can not only take it to pieces in that way, but can also put the pieces together again by forcing oxygen and hydrogen gases to combine and form water.

There can be no doubt, therefore, that water is not a continuous substance, but made up of two substances. And then the chemist finds that the two substances, oxygen and hydrogen, of which water is made up, are neither of them continuous substances, but are both made up of exceedingly minute parts called molecules in vast numbers, and that these molecules are themselves made up of parts in the shape of atoms. In fact, the chemist finds that water is made up of molecules, each of which consists of two atoms of hydrogen united to one atom

of oxygen. But we have found that the molecules of substances are united to form masses by the operation of a fluid representing energy of attraction, which also unites atoms to form molecules. Now, there is, as we have seen, no longer any doubt that matter is made up of parts in the shape of atoms, and is not continuous.

But the question is, whether the fluid energy which unites atoms is also made up of parts?

Now we know that water can be divided up into separate drops, each of which, when the water is perfectly pure, has exactly the same composition as the main body of water from which it was derived. But if a quantity of water can thus be divided up into drops, and thus not only some of the molecules of which it is made up separated from others, but also some of the fluid energy, which binds its molecules together, separated from the rest, we are forced to conclude that energy, like matter, is made up of parts, and of very minute parts, since water in the form of mist occurs in very minute drops. Here we may notice that Professor J. J. Thomson and Sir William Crookes have apparently demonstrated experimentally the fact that energy is made up of parts.

"In some experiments described in the *Phil. Mag.*, October 1897, I showed," says Professor J. J. Thomson, "that in the kathode rays there were present bodies whose mass was exceedingly small compared with the masses of ordinary atoms; these masses,

which carry a charge of negative electricity, I called 'corpuscles.'"¹

Sir William Crookes tells us that what he "called 'radiant matter' now passes as 'electrons,'" and that "electrons are the same as . . . the corpuscles . . . of J. J. Thomson."

He tells us also that "according to J. J. Thomson the mass of an electron is about the $\frac{1}{1836}$ th part of that of the hydrogen atom," and that "many experiments . . . show that the liberated electrons do not behave as a gas, *i.e.* they have not properties dependent on intercollisions, mean free path, &c.; they act more like a fog or mist . . . clinging to positively electrified bodies."²

Now we know that a fog or a mist is made up of minute drops of water, and thus of fluid drops, and therefore we see that Professor J. J. Thomson's corpuscles have fluid analogies.

Hence we have apparently in Professor J. J. Thomson's corpuscles and in Sir William Crookes' radiant matter got very near to a practical demonstration of the correctness of the view we have long been putting forward, that energy is fluid in constitution and made up of fluid parts, while matter is solid in constitution and made up of solid parts or atoms.

In this connection, we note that Sir William Crookes tells us that he said of radiant matter that

¹ *Nature*, vol. lxii. p. 31.

² A paper read at the Royal Society on 6th February 1902; see *Nature*, vol. lxxv. p. 377.

"in other properties it almost assumes the character of radiant energy."¹

If we remember what Faraday has told us, namely, that "a particle of oxygen is ever a particle of oxygen—nothing can in the least wear it,"² and accept him as a guide; and if we further bear in mind the fact that at a joint discussion held by the Physical and Chemical Sections of the British Association at Bradford in September 1901 the Chemical Section stated, by Professor H. E. Armstrong, that in the opinion of chemists the atoms were permanent and stable, and that the removal of $\frac{1}{1000}$ th of the mass of a hydrogen atom along with its negative charge seemed to them impossible:³ we shall see that Professor J. J. Thomson's corpuscles cannot be parts of matter, and can only be parts of energy, if science is right in its conclusion that matter and energy are the only realities.

If now we remember what Sir William Crookes has told us in regard to electrons "clinging to positively electrified bodies" in the quotation given above, and take note of the fact that electrons are able to cling to bodies, we shall scarcely doubt that we are getting very close to Newton's Agents in Nature, "which are able to make the particles of bodies stick together by very strong Attractions."

¹ A paper read at the Royal Society on 6th February 1902; see *Nature*, vol. lxxv. p. 377.

² "Experimental Researches in Chemistry and Physics," p. 454.

³ *Nature*, vol. lxxii. p. 564.

We have arrived at the conclusion that energy is made up of fluid parts. And since a fluid has both a stream or moving form, corresponding to the kinetic form of energy, and a pool or resting form, corresponding to the potential form of energy, and can readily pass from one form to the other; and since a fluid has also a wave form or sympathetic form or form of communication, corresponding to the wave form of energy: we perceive that fluid parts will provide us with transport, and with the binding and connecting materials which we require for the formation of bodies and systems of bodies. To obtain the form of the fluid parts of which energy is made up we must go to physiology. The human builder can transport bricks and put them together, can form streams of human beings each bearing a load, and can also form piles of brickwork, in which the bricks are accurately put together.

But Evolution sends us back to the earliest forms of life, and physiology shows us minute fluid bodies amongst the protozoa; and shows, moreover, that these minute fluid bodies are able, each in its own person, at will to assume a moving form or stream form in which it elongates itself and streams out, or to assume a resting or pool form, and to pass from one form to the other. Physiology further shows amongst the protozoa minute structureless fluid bodies, in the shape of masses of slime, which are able at will to throw out from any part of their

surfaces minute thread-like processes in the shape of pseudopodia, by which they are able to lay hold of surfaces. These pseudopodia can not only be extruded from any part of the surface, but can be retracted at any time, and absorbed into the body of the protozoon.

These minute bodies can collect together in masses, as shown by the mycetozoa, and these masses, as shown by Sir J. S. Burdon Sanderson in his opening address to the British Association in 1893, are subject to allurements.

The amœba, or one of the amœboid forms, is the typical form for these protozoa.

The ordinary amœba is an extremely sluggish body: but an ideal amœba, made up of a subtle fluid of such tenuity as to have the power of instantaneously elongating or retracting itself or its pseudopodia, will furnish us, as already shown in "Argon and Newton: a Realisation," Chapter IV., with an ideal form for the parts of the fluid, or rather of the fluids, which represent energy.

Thus we get matter made up of minute, solid, inert atoms. And we get energy made up of minute fluid corpuscles, able to assume instantaneously either an elongated moving or stream form, or a compact, quiescent, pool form; able also to pass rapidly backwards and forwards from the stream to the pool form, and thus to assume a quivering or wave form; and able also to extrude instantaneously

at any part of their surface pseudopodia by which to lay hold either of atoms of matter or of other corpuscles in contact with them. We have got Newton's atom, Newton's Agents in Nature, and Leibnitz's monad brought together.

In the case of Matter we work back from masses to molecules, and from molecules to atoms or small parts of matter. And in the case of life we work back from body to cell, and from cell to corpuscles or small parts of energy. And with self-active corpuscles we have voluntary movement as a fundamental characteristic.

In this connection we may note that Professor James Ward pointed out that "it is especially interesting to find that even Kant at length—in his latest work, the posthumous treatise on the 'Connexion of Physics and Metaphysics' . . . came to see the fundamental character of voluntary movement."¹

It is clear that amœboid fluid bodies, able to lay hold of solid substances, and able also to assume an elongated or stream form, and to pass from an elongated into a disc or film form, would be able to draw two small bodies together, by reaching out in an elongated form from one to the other, so as to get hold of both, and then spreading out in a disc or film form between them while keeping hold of both: just as a drop of water between two plates of glass

¹ "Naturalism and Agnosticism," vol. ii. p. 191.

draws them, as we have seen, forcibly together by passing from the drop form into a film form.

It is clear, therefore, from the case of the drop of water between two plates of glass, which exerts, as we have seen, enormous force upon the plates of glass, that amœboid fluid bodies of the requisite strength would be able to draw the particles of bodies together, and make them stick together by very strong attractions. Hence we conclude that in amœboid fluid bodies we have found Newton's "Agents in Nature able to make the particles of bodies stick together by strong attractions;" and that we have found them very near to the place where Newton was looking for them.

We perceive now that with Newton's agents in the form of living beings of the very lowest kind indeed, but still living, we are coming very close to a realisation of the view which the great physiological chemist, Professor Bunge, put forward in connection with Life, when he said that "the mechanical theories of the present will assuredly carry us eventually to the vitalism of the future."¹

We have also a realisation of Ruskin's view when he remarks that "You may at least earnestly believe, that the presence of the spirit which culminates in your own life, shows itself in dawning, wherever the dust of the earth begins to assume any orderly

¹ "Physiological and Pathological Chemistry," translated by Wooldridge, p. 13.

and lovely state. . . . Things are not either wholly alive, or wholly dead. They are less or more alive.”¹

We have also a realisation of the views enunciated by Professor Balfour Stewart and Professor P. G. Tait in the passage which runs thus: “I feel myself compelled to believe that *all kinds of matter have their motions associated with certain simple sensations*: in other words, all matter is, in some occult sense, *alive*.”²

We have also a realisation of Professor von Nägeli's views as explained by Clerk Maxwell. “This,” says Clerk Maxwell, “is what we may call the ‘levelling up’ policy, and it has been expounded with great clearness by Professor von Nägeli. . . . He can draw no line across the chain of being and say that sensation and consciousness do not extend below that line. He cannot doubt that every molecule possesses something related, though distantly, to sensation.”³

And we may even claim Mr. Herbert Spencer's support. For he tells us that “when the explorer of Nature sees that, quiescent as they appear, surrounding solid bodies are thus sensitive to forces which are infinitesimal in their amounts . . . the conception to which he tends is much less that of

¹ “Ethics of the Dust,” tenth edition, p. 211.

² “Paradoxical Philosophy,” p. 78.

³ “Scientific Papers of James Clerk Maxwell,” edited by Niven, vol. ii. p. 761.

a Universe of dead matter than that of a Universe everywhere alive: alive, if not in the restricted sense, still in a general sense.”¹

And he also tells us that “this necessity we are under, to think of the external energy in terms of the internal energy, gives rather a spiritualistic than a materialistic aspect to the Universe.”² We have also manifestly got very close to Professor Ernst Haeckel’s view of the universe, only with dualism in place of the pure monism which he has in contemplation.

Professor Ernst Haeckel says: “We hold, with Goethe, that ‘matter cannot exist and be operative without spirit, nor spirit without matter.’ We adhere firmly to the pure unequivocal monism of Spinoza. Matter, or infinitely-extended substance, and Spirit (or Energy), or sensitive and thinking substance, are the two fundamental attributes, or principal properties, of the all-embracing divine essence of the world, the universal substance.”³ And Professor Ernst Haeckel also says that, “As to my own opinion—and that of many other scientists—I must lay down the following theses, which are involved in Vogt’s pyknotic theory, as indispensable for a truly monistic view of substance, and one that covers the whole field of organic and inorganic nature:—

(i.) The two fundamental forms of substance,

¹ “Principles of Sociology,” vol. iii. p. 172.

² *Ibid.* p. 173.

³ “Riddle of the Universe,” translated by J. McCabe, p. 21.

ponderable matter and ether, are not dead, and only moved by extrinsic force, but they are endowed with sensation and will (though naturally of the lowest grade); they experience an inclination for condensation, a dislike of strain; they strive after the one and struggle against the other.

- (ii.) There is no such thing as empty space; that part of space which is not occupied with ponderable atoms is filled with ether.
- (iii.) There is no such thing as an action at a distance through perfectly empty space; all action of bodies upon each other is either determined by immediate contact or is effected by the mediation of ether.”¹

From the above quotations it will be seen that in the best of the thinking which has been done in our day there is a convergence of opinion towards the view that the universe is in some sense a living universe; is throughout a living universe; and is, in fact, a universe which has been built up by life, and is kept together by life.

It must seem strange to those who simply observe and do not think to find two philosophers so opposed in opinion as Mr. Herbert Spencer and Professor Tait, yet agreeing in the view that matter is in some sense alive.

¹ “The Riddle of the Universe,” translated by J. McCabe, p. 225.

CHAPTER V

ANTAGONISM

WE have tried to show in the last chapter experimentally the existence of fluid attraction, and to show the *modus operandi* by the behaviour of a drop of water between two plates of glass when they are close enough together to enable the drop to lay hold of both and spread out between them. We have also tried to obtain from Physiology for Newton's Agents in Nature a fluid form in which they will be able to lay hold of solid bodies and draw them together if not too large to be moved, and thus work out a fluid attraction.

We have found that fluid corpuscles able to lay hold of solid bodies and able also to pass from an elongated to a flattened or film form, or *vice versa*, will be, as shown by the case of a drop of water when it gets between two plates of glass and draws them together by spreading out into a film, able to draw two bodies together by getting between them and laying hold of both in an elongated form, and then, while keeping hold of both, spreading out into a film between them. If, however, these

fluid corpuscles are as small as Professor J. J. Thomson's researches seem to show they are, they will have a mass of about the $\frac{1}{1700}$ th part of the mass of a hydrogen atom, or perhaps be far smaller still, if, as seems possible, Professor J. J. Thomson's corpuscles are in reality systems or aggregations of far smaller bodies. In any case, it is not likely that fluid corpuscles so small as these would singly be able to draw atoms or molecules together; but if they operated in rows between atoms, with all the corpuscles in each row connected together, and the end corpuscles in each row attached to atoms of matter, a row of corpuscles might conceivably by co-operation draw the atoms together if the corpuscles collectively spread themselves out so as to convert the row into a film. We conclude therefore, that Attraction implies Co-operation.

The importance of this conclusion will be seen when we pass, as we must now do, to Dispersion, which confronts us, as we have already seen, in the Kinetic Theory of Gases.

The Kinetic Theory of Gases shows us, as we have seen at p. 27, the atoms in the case of ideal gases flying in all directions independently of each other, and not keeping together even when they come together in collisions; and thus it shows us atoms dispersed in space and thus Dispersion.

With our view we have no difficulty in showing at once by experiments the existence of fluid

Dispersion. In fact, we have only to drop a lump of salt or sugar into a quantity of pure water to get fluid Dispersion.

We all know that the lump of salt or sugar, if not too large, will in course of time be dissolved, and we find that what really occurs is that the lump of salt or sugar is pulled to pieces, and the molecules of salt or sugar are distributed throughout the water. That the case is so is plain from the fact that the molecules of salt or sugar can be recovered by simply boiling off the water.

Hence, in cases of solutions of salt or sugar in pure water we have plainly got cases of fluid Dispersion of molecules. Arrhenius, indeed, as we learn,¹ supposes that in the case of solutions which conduct electricity freely even the molecules are split up into their constituent ions. We notice that this view supposes Dispersion to be carried a stage further than it is carried in the cases of solutions of sugar and salt, in which lumps are broken up into molecules and not molecules into atoms.

The same explanation will manifestly cover both cases with our view that atoms are built up into molecules by the same cause, namely, the operations of Newton's Agents in Nature, as molecules are built up into masses. For it is plain that any

¹ "An Introduction to Physical Chemistry," by James Walker, first edition, p. 220.

cause which suffices to break up masses into molecules will, if strong enough to carry its operations one stage further, suffice to break up molecules into atoms. We will confine ourselves, therefore, for the present to the first case, that of breaking up masses into molecules, because we have in solutions of salt and sugar clear experimental evidence in regard to it.

Now we notice at once the remarkable fact, that the fluid which gives us, in solutions of salt and sugar, experimental evidence of the existence of fluid Dispersion, is the same fluid, namely water, as that which gives us in water of crystallisation, and in the case of drops of water between plates of glass, fluid Attraction.

Since now Dispersion clearly represents activity just as much as Attraction represents activity, and since activity is due, as we have seen at page 16, to energy, we are driven at once, from the fact that water gives us both phenomena of Attraction and phenomena of Dispersion, to the conclusion that there must be in water energy of two forms, namely, energy of Attraction and energy of Dispersion.

In fact, we arrive at once at the conclusion that if we simply take away from water molecules Newton's "Agents in Nature, able to make the particles of bodies stick together by very strong Attractions," and replace them by the other form of energy; then energy of Repulsion will straightway

disperse the molecules in space in the state shown by the Kinetic Theory of Gases.

In fact, we can bring forward experimental evidence pointing to the correctness of this conclusion. For if we simply apply heat to the water, and at the same time take off pressure, the water will be converted into steam, and thus dispersed in the state indicated by the Kinetic Theory of Gases.

Or if, on the other hand, we take steam, and cool it by taking off heat from it while it is under pressure, we shall convert it first into water, and then into solid ice if the process of cooling it under pressure is continued.

Now, in this view the assumption is made that the act of taking off pressure effects a dislodgment of energy of Attraction, and the act of putting on pressure entails the dislodgment of energy of Dispersion.

It is easy to show that pressure causes a rise of temperature, under which heat is given off to surrounding substances, and thus that the application of pressure effects the dislodgment of energy of Dispersion. But it was not possible to show that taking off pressure effects a dislodgment of Attractive energy until Professor J. J. Thomson and Sir William Crookes showed that when the exhaustion of a tube is carried very far, and then a current of electricity is passed between electrodes inside the tube, radiant matter, consisting of corpuscles or

electrons, with charges of negative electricity, and mass only $\frac{1}{1836}$ th part of the mass of a hydrogen atom, are shot off from the negative electrode.

For reasons already given at p. 103, we conclude that these corpuscles or electrons are energy bodies, and not atoms of matter, and being such represent a dislodgment of energy of Attraction effected by the reduction of pressure in the tube.

We can see with this view why, as Sir William Crookes observes, no positive electrons are found; for, if we are right, negative electricity, for reasons which will presently be given, is connected with energy of Attraction, and positive electricity with energy of Dispersion.

With our view then energy of Dispersion holds the field in an exhausted tube, and it is energy of Attraction which is dislodged.

Positive electrons, if obtainable at all, will, according to our view, be obtainable in exactly the opposite way, namely, by high pressure. Having shown thus that the existence of fluid Attraction and fluid Dispersion can be demonstrated by experiments; and that Attraction and Dispersion are, according to the conclusions of Science, both referable to energy, and thus imply the existence of energy of two opposite kinds; and having further shown by experiments that these two forms of energy reside side by side in molecules of matter, and can under favourable circumstances dislodge and replace each

other, and therefore must exist in a state of Antagonism, we are led at once to the conclusion that if energy is a reality as science takes it, as we have seen it to be, its two forms, which can dislodge and replace each other, must both of them be similarly constituted.

From this view it follows that if energy of Attraction has parts, in the shape of Newton's Agents in Nature, which take the form of amœboid fluid corpuscles, able to lay hold of atoms of matter, and able also to lay hold of each other, as we have found it to have; then energy of Dispersion must also consist of parts, in the form of amœboid fluid corpuscles, able to lay hold of atoms of matter.

But now comes this question—If energy of Dispersion is made up of parts which have the same form as those of energy of Attraction, why does not energy of Dispersion draw atoms together, and thus attract them instead of dispersing them?

The answer to this, according to our view, is to be found in the fact, pointed out on page 112, that Attraction can only be effected by co-operation: and that the parts of energy of Dispersion do not co-operate; but simply compete with each other, for the possession of the atoms of matter, forcing their way in upon them, and laying hold of them whenever possible, and always pressing upon and endeavouring to oust any corpuscles which lie between themselves, and the nearest atom of matter.

According to our view, then, Dispersion and Attraction are both effected by energy, made up of minute parts in the form of amœboid fluid corpuscles, with a tendency to lay hold of atoms of matter; but Dispersion is the effect of competition, pure and simple, for possession of the atoms, while Attraction is the effect of co-operation.

According to our view, then, the solution of a lump of sugar by a quantity of pure water is due to activity amongst the corpuscles of energy of Dispersion resident upon the molecules of water. A portion of these corpuscles force their way in between the molecules of sugar, and separate them much after the same way as molecules of water in the form of steam force themselves in between the piston and one end of a cylinder in a steam-engine, and separate the two by driving the piston to the other end of the cylinder.

We notice that the steam if heated, or rather superheated, drives the piston more rapidly, and thus separates the piston and the end of the cylinder more readily than steam at ordinary temperatures can do: and so too we find that if water is heated it will separate the molecules of sugar more readily than water at ordinary temperature will do.

We are able now to deal with the case of an ideal gas in the state shown by the Kinetic Theory of Gases before Attraction made its appearance.

In this state we have, according to our view, fluid corpuscles of energy of Dispersion in vast numbers dealing with a comparatively small number of atoms of matter, without the disturbing presence of any corpuscles of energy of Attraction; so that the number of corpuscles of energy of Dispersion, which are able directly to lay hold of the atoms, is very small in comparison with the vast majority which are unable to satisfy their tendency to lay hold of the atoms by direct contact, and which press in upon corpuscles in actual possession from all sides, and endeavour to oust them.

There will thus be about each atom a centre of high pressure on the side on which the largest number of corpuscles are pressing upon it, and a centre of low pressure on the side on which the smallest number of corpuscles are pressing upon it.

We know that the rapid formation of centres of high and low pressure in fluids is attended with the production of storms, from our experience with the storms of wind which take place in our own atmosphere: and we know that solid particles of sand or dust or other forms of matter are swept along with great velocity by violent storms.

We conclude, therefore, that in a subtle fluid, such as that formed by energy of Dispersion, the establishment of centres of high and low pressure about atoms would likewise give rise to storms. Instead, however, of having, as in the case of our

atmosphere, storms occurring on a large scale, and sweeping vast numbers of grains of sand and other solid particles along together; we should have with fluid energy of Dispersion a separate storm, occurring about each atom, and sweeping the atom along from the direction of high pressure towards the direction of low pressure, or line of least resistance.

Thus the atoms would be carried hither and thither, being blown in all directions, until they were uniformly diffused and distributed throughout space, and a state of equilibrium was established, as doubtless it would be in course of time, even though it would have to be established throughout the immensity of space.

The point for us, however, is that an equilibrium of this kind would be at once upset by the intrusion of corpuscles of another kind, such as those of energy of Attraction, in sufficient strength to effect the gradual dislodgment and displacement of the corpuscles of energy of Dispersion.

The atoms would, as we conclude, resume their wild flight in all directions under the pressure of the competition of the corpuscles of energy of Dispersion, and continue it until these corpuscles were gradually dislodged and displaced by the intrusion of corpuscles of energy of Attraction, and the atoms laid hold of, drawn together and built up into molecules, masses, bodies, and planetary and solar systems.

Hence we see that Antagonism gives us the key to the situation before us, and that a real Antagonism is at the root of the present order of things.

Here we may notice that Professor Huxley has quoted the saying of wise old Heraclitus, that "Strife is the father and king of all things."

We find, too, that Professor Huxley clearly pointed out the universality of Antagonism. "The more," he says, "we learn of the nature of things the more evident is it that what we call rest is only unperceived activity; that seeming peace is silent but strenuous battle. In every part, at every moment, the state of the cosmos is the expression of a transitory adjustment of contending forces. . . . What is true of each part, is true of the whole."¹

In regard to Mr. Herbert Spencer's philosophy we find, as indeed we have already pointed out elsewhere, that he has, to our mind, fully demonstrated the universality of Antagonism.

"Matter," he says, "cannot be conceived except as manifesting forces of attraction and repulsion. Body is distinguished in our consciousness from Space, by its opposition to our muscular energies; and this opposition we feel under the twofold form of a cohesion that hinders our efforts to rend, and a resistance that hinders our efforts to compress. . . . Probably this conception of antagonistic forces

¹ "Evolution and Ethics," p. 4.

is originally derived from the antagonism of our flexor and extensor muscles. But be this as it may, we are obliged to think of all objects as made up of parts that attract and repel each other, since this is the form of our experience of all objects.”¹

We notice that he believes that all motion is rhythmical;² and says that “rhythm results wherever there is a conflict of forces not in equilibrium.” “If,” he goes on to say, “the antagonist forces at any point are balanced, there is rest; and in the absence of motion there can, of course, be no rhythm. But if instead of a balance there is an excess of force in one direction—if, as necessarily follows, motion is set up in that direction . . . and if the movement cannot be uniform, then in the absence of acceleration or retardation continued through infinite time and space (results which cannot be conceived), the only alternative is rhythm.”³

From these statements we gather that Mr. Herbert Spencer holds that motion is connected with a conflict between forces.

He tells us also what the forces are which give rise to motion.

“From universally co-existent forces of attraction and repulsion,” he says, “there result certain laws of direction of all movement. Where attractive

¹ “First Principles,” fifth edition, p. 224.

² Ibid., p. 253.

³ Ibid., p. 254.

forces alone are concerned, or rather are alone appreciable, movement takes place in the direction of their resultant; which may, in a sense, be called the line of greatest traction. Where repulsive forces alone are concerned, or rather are alone appreciable, movement takes place along their resultant, which is usually known as the line of least resistance."¹

Thus we gather that the Antagonism manifested in connection with motion is the same Antagonism as is manifested in connection with the structure of matter, namely, an Antagonism between forces of Attraction and forces of Repulsion.

Finally, we have the universality of Antagonism recognised in connection with equilibration.

"That universal co-existence of antagonist forces," he says, "which, as we before saw, necessitates the universality of rhythm, and which, as we before saw, necessitates the decomposition of every force into divergent forces, at the same time necessitates the ultimate establishment of a balance."²

Hence we find that Mr. Herbert Spencer has fully established the universality of Antagonism, but at the same time we gather that he does not admit the reality of the Antagonism thus established.

We have not succeeded in finding any explicit statement of the reasons for concluding that the

¹ "First Principles," fifth edition, p. 225.

² Ibid., p. 484.

Antagonism, which thus appears to us to be so firmly established, is not a real Antagonism.

We gather, however, that the reason for holding that the Antagonism thus shown to exist is not a real Antagonism, is based upon the assumption that the facts brought forward in the chapter on "The Transformation and Equivalence of Forces" in "First Principles" show that there is a "law of metamorphosis which holds among the physical forces,"¹ and that under this law the forces of Attraction and Repulsion, which appear to be antagonistic, can by suitable arrangements be converted into each other—Attraction into Repulsion and Repulsion into Attraction—and thus that "phenomena are due to the variously conditioned workings of a single force."²

With this view "these universally co-existent forces of attraction and repulsion must not be taken as realities, but as our symbols of the reality. They are the forms under which the workings of the Unknowable are cognisable by us—modes of the Unconditioned as presented under the conditions of our consciousness."³

And in connection with this view we find a remark to the effect that "magnetism, heat, light, &c., which were a while since spoken of as so many distinct imponderables, physicists are now beginning to regard as different modes of manifestation of some one universal force."⁴

¹ "First Principles," fifth edition, p. 217.

² *Ibid.*, p. 223.

³ *Ibid.*, p. 225.

⁴ *Ibid.*, p. 105.

This, of course, makes Antagonism altogether unreal, and makes out Force to be something quite beyond our powers of comprehension. With this view "it is," as Mr. Herbert Spencer says, "impossible to form any idea of Force in itself," and "equally impossible to comprehend its mode of exercise."¹

But, while we gather that Mr. Herbert Spencer takes this view himself, and thus takes Antagonism to be unreal, we gather also that he recognises that facts are not decisively in favour of this view, and that there is plenty of room for the opposite view that Antagonism is real, and that phenomena "are due to the conflict of two forces." For he remarks that "we cannot decide between the alternative suppositions, that phenomena are due to the variously-conditioned workings of a single force, and that they are due to the conflict of two forces."²

This, of course, is a very important admission for us, in view of the fact which we have been trying to show that fluid Dispersion, as shown in the Kinetic Theory of Gases, when taken along with fluid Attraction, as shown in gravitation, chemical union, and cohesion, furnishes decisive proof of the reality of Antagonism, and shows us how and why Antagonism came in. Indeed, we find that Mr. Herbert Spencer himself has noted in

¹ "First Principles," fifth edition, p. 61.

² *Ibid.*, p. 223.

connection with the suffering caused by parasites that "with the conception of two antagonist powers which severally work good and evil in the world the facts are congruous enough."¹

But if we turn now to Sir William R. Grove, we shall find no indecision in his views in regard to Antagonism.

In a lecture on Antagonism, delivered at the Royal Institution on the 20th April 1888, we find that Sir William R. Grove stated that "the universality of Antagonism has not received the attention it seems to me to deserve." And he also stated in regard to Antagonism, that "my theory—call it, if you will, speculation—is that it is a necessity of existence, and of the organism of the universe, so far as we understand it; that motion and life cannot go on without it; that it is not a mere casual adjunct of Nature, but that without it there would be no Nature, at all events, as we conceive it; that it is inevitably associated with unorganised matter, with organised matter, and with sentient beings."²

We have laid stress upon the entire absence of indecision in Sir William R. Grove's views in regard to the reality of Antagonism, because we gather that Mr. Herbert Spencer mainly relied on Sir William R. Grove for the facts which "show us that each force is transformable, directly or indirectly,

¹ "Principles of Biology," vol. i., revised edition, p. 429.

² *Nature*, vol. xxxvii., No. 965, p. 617.

into the others;" since Mr. Herbert Spencer tells us that the larger part "are culled from Mr. Grove's work on 'The Correlation of Physical Forces.'" ¹

Thus, while on the one hand we find Mr. Herbert Spencer admittedly making use of facts supplied by Sir William R. Grove; on the other hand, we find Sir William R. Grove, in his lecture on "Antagonism," referred to above, stating that "the universality of Antagonism has not received the attention it seems to me to deserve," and then going on to make a direct reference to Darwin's and Professor Huxley's work, and also to Mr. Herbert Spencer's work. ²

We find, therefore, that Professor Huxley and Sir William R. Grove both recognised the existence of Antagonism, and that Mr. Herbert Spencer also recognised its existence in an unreal form.

But we further find that a view of the constitution of the universe, which Professor Ernst Haeckel favours, also recognises the existence of Antagonism.

In regard to this view, Professor Ernst Haeckel remarks, that "in fundamental opposition to the theory of vibration, or the kinetic theory of substance, we have the modern '*theory of condensation*' or the pyknotic theory of substance. It is most ably established in the suggestive work of J. C. Vogt on '*The Nature of Electricity and Magnetism on the Basis of a Simplified Conception of Substance*' (1891).

¹ "First Principles," fifth edition, p. 201.

² *Nature*, vol. xxxvii., No. 965, p. 617.

Vogt assumes the primitive force of the world, the universal *prodynamis*, to be, not the vibration or oscillation of particles in empty space, but the condensation of a simple primitive substance, which fills the infinity of space in an unbroken continuity. Its sole inherent mechanical form of activity consists in a tendency to condensation or contraction, which produces infinitesimal centres of condensation. . . . These . . . centres of condensation, which might be called '*pyknotoms*,' correspond in general to the ultimate separate atoms of the kinetic theory; they differ, however, very considerably, in that they are credited with sensation and inclination (or will movement of the simplest form), *with souls*, in a certain sense. . . . Moreover, these 'atoms with souls' do not float in empty space, but in the continuous, extremely attenuated intermediate substance, which represents the uncondensed portion of the primitive matter. By means of certain 'constellations, centres of perturbation, or systems of deformation,' great masses of centres of condensation quickly unite in immense proportions, and so obtain a preponderance over the surrounding masses. By that process the primitive substance, which in its original state of quiescence had the same mean consistency throughout, divides, or differentiates into two kinds. The centres of disturbance, which *positively* exceed the mean consistency in virtue of the *pyknosis*, or condensation, form the ponderable

matter of bodies; the finer, intermediate substance, which occupies the space between them, and *negatively* falls below the mean consistency, forms the ether, or imponderable matter. As a consequence of this division into mass and ether, there ensues a ceaseless struggle between the two antagonistic elements, and this struggle is the source of all physical processes. The positive ponderable matter, the element with the feeling of like or desire, is continually striving to complete the process of condensation. . . . The negative imponderable matter, on the other hand, offers a perpetual and equal resistance to the further increase of its strain, and of the feeling of dislike connected therewith. . . . We cannot go any further here into the details of the brilliant theory of J. C. Vogt. . . . I am myself too little informed in physics and mathematics to enter into a critical discussion of its lights and shades; still I think that this pyknotic theory of substance will prove more acceptable to every biologist who is convinced of the unity of nature, than the kinetic theory which prevails in physics to-day."¹

In reference to this explanation, we notice that it recognises the existence of "atoms with souls," which "are credited with sensation and inclination (or will-movement of the simplest form)," and thus, in effect, recognises the existence of Leibnitz's monads, which Leibnitz held to be the true "atoms of Nature," and

¹ "The Riddle of the Universe," p. 222.

also to be self-active living beings endowed with the perceptive and appetitive faculty. Thus we have a distinguished biologist and evolutionist recognising the existence of monads; and thus, so far, in agreement with ourselves, since our view also recognises the existence of monads in the shape of fluid corpuscles, and of Newton's Agents in Nature.

The next point in the above explanation is that it recognises the existence of Antagonism by taking "the source of all physical processes" to be "a ceaseless struggle between the two antagonistic elements."

And so far it is still in complete agreement with our view; for we too, as shown at p. 121, take all physical processes to be the result of a ceaseless struggle.

But then we find that the explanation, which is favoured by Professor Ernst Haeckel, takes the struggle, which is "the source of all physical processes," to be between "ponderable matter," which "is continually striving to complete the process of condensation," and "imponderable matter," which "offers a perpetual and equal resistance"; and thus plainly makes ponderable matter and energy both equally active. Hence it is contrary to the view accepted by science, which takes, as we have seen at p. 16, matter to be inert and energy alone to be active.

By taking, as we do, matter to be inert, and to be

the ground of Antagonism between two forms of energy, which are ceaselessly struggling over the possession of atoms of matter, we get a view, which is not only in accordance with the conclusions of science, in regard to the inertness of matter and the activity of energy, but is also in accordance with the conclusions of science, in regard to the Kinetic Theory of Gases, which is discarded by the explanation favoured by Professor Ernst Haeckel. That explanation is, as Professor Ernst Haeckel points out in the passage quoted above, "in fundamental opposition to the . . . kinetic theory of substance."

And Professor Ernst Haeckel thinks that Vogt's theory "has rendered a very good service in eliminating the untenable principle of the kinetic theory of substance. "Modern Physics," says Professor Ernst Haeckel, "for the most part, still firmly adheres to the older theory of vibration, to the idea of an *actio in distans*, and the eternal vibration of dead atoms in empty space."¹

But Professor Ernst Haeckel, in his theses, which are given at p. 109, denies the existence of empty space and the possibility of action at a distance.

Hence we conclude that his objection to the Kinetic theory is grounded upon the idea that it implies the existence of empty space, and also the possibility of action at a distance.

We have endeavoured, however, to show at p. 118

¹ "The Riddle of the Universe," p. 224.

that a fluid explanation of the Kinetic theory is possible; and that the atoms, instead of dancing in empty space, may be kept in a state of constant agitation by the competition which will arise amongst the parts of a fluid for possession of the atoms, if the parts of the fluid have a strong affinity for the atoms, and at the same time the number of atoms is altogether insufficient to enable every part of the fluid to satisfy its affinity by taking hold of an atom.

We have, in fact, endeavoured to show that the Kinetic Theory of Gases represents a particular case in fluid Dispersion, which, in a general form, can be shown experimentally to occur when a lump of salt or sugar is dissolved in a quantity of water.

And since we can show experimentally, as pointed out at p. 86, the existence of fluid Attraction as well as the existence of fluid Dispersion, and show, moreover, that things must be separated or scattered before they can be attracted, we find, for our part, the Kinetic Theory of Gases a necessary part of philosophy instead of discarding it.

In this way we can show that our explanation embodies the conclusions of science, and embodies also, except in one point, Professor Ernst Haeckel's conclusions, and brings all into harmony, not excluding the Kinetic Theory of Gases.

The one part of Professor Ernst Haeckel's conclusions which cannot be realised is his monism.

Our explanation shows that the "ceaseless struggle between the two antagonistic elements," which is recognised as being "the source of all physical processes," can only be explained in accordance with the conclusions of science by dualism, and cannot be explained by monism.

We point to the fact that the Kinetic Theory of Gases, with the separation and dispersion of atoms which it shows, supplies a sufficient explanation and reason for the struggle in the fact, pointed out at p. 29, that atoms, actuated by energy which tends to scatter, cannot be brought together by Attraction without having the energy which tends to displace them overcome; and thus without a struggle.

The reasonableness of the view, that the solid atom is the ground of contention, can be shown experimentally by pointing to the readiness with which fluids dissolve solids (as when, for example, water dissolves a lump of salt), as showing affinity in the molecules of water for the solid molecules in the lump of salt.

We have pointed out above that our explanation is in agreement with Professor Ernst Haeckel's conclusions, except in giving a dualistic interpretation of the cosmos in place of the monistic explanation which he upholds. It may, however, be well to point out that the dualism of our explanation is not open to all the objections which Professor Ernst Haeckel raises against dualism in general.

"All the different philosophical tendencies," says Professor Ernst Haeckel, "may, from the point of view of modern science, be arranged in two antagonistic groups: they represent either a *dualistic* or a *monistic* interpretation of the cosmos. The former is usually bound up with teleological and idealistic dogmas, the latter with mechanical and realistic theories."¹

But our dualistic explanation, in place of being dogmatic, is based throughout upon facts: and, moreover, is so realistic that we are not merely able to show the nature of the things which operate in it; but have found ourselves able, in Chapters III. and IV., to deduce real forms for them. Manifestly it is impossible for any explanation to carry realism further than that. Our explanation cannot, therefore, be objected to on the ground that it is dogmatic, or on the ground of its being insufficiently realistic.

Our explanation, therefore, meets all the objections Professor Ernst Haeckel raises against dualism, except the objection that it is teleological.

That, however, is no valid objection from a scientific point of view, but simply shows that the solution of the riddle with which Professor Ernst Haeckel deals can only be obtained by taking account of the revelations of religion. It shows that if we reject the revelations of

¹ "The Riddle of the Universe," p. 20.

religion, the revelations of science will simply mystify us.

We, therefore, believe that we have got an Antagonism which solves "The Riddle of the Universe," and meets the requirements of Professor Ernst Haeckel's philosophy.

CHAPTER VI

THE ANTAGONISTS

IN the preceding chapters we have tried to show that our universe, in its present form, is the immediate result of a conflict between two real Antagonists over the possession of atoms of matter in the form of inert solid bodies, fashioned in such a way as to fit them for building molecules, and left unalterable in form, and thus as building materials.

We have found that these building materials, after being accurately dressed, or pieced together, were picked up and carried off by a host of fluid corpuscles, which, as shown by the Kinetic Theory of Gases, made no use of them for building purposes, but simply competed with each other for possession of the atoms, all pressing upon the atoms, and those not in possession striving to oust those that were.

In consequence of this wild competition, the atoms were dispersed throughout space in wild confusion, instead of being used in the construction of the forms of wondrous beauty which might have been built with them, as shown by many forms of

exquisite loveliness in crystals, leaves, flowers, scales, and feathers in the world to-day.

When the atoms were thus scattered and dispersed, the purpose for which they were prepared so accurately and carefully, as the Periodic System of chemistry shows them to have been prepared, was completely disregarded or lost sight of. We are shown, in fact, the atoms in the hands of an enemy or of a rebel.

It was necessary, therefore, to recover the atoms by force.

The universe, as we see it before us now, is, according to our view, the result of the conflict for the recovery of the atoms.

We have the atoms laid hold of, and brought in stage by stage, and stored up for safe custody in temporary buildings, for use, as we learn from religion, in better buildings hereafter.

We have, as shown in chemistry, atom drawn to atom to form molecules, first of the simple kind, as shown in binary compounds, which have molecules formed of atoms of two kinds only, then of the complex kinds, formed by uniting simple molecules of different kinds together, or by putting on to them additional atoms of kinds other than or the same as those of which they are composed.

Then we have molecules united together by cohesion to form masses or bodies, first of the liquid kind, then of the solid kind.

Then we have bodies united by gravitation into systems, planetary and solar.

We have found that the recovery of the atoms is being effected by fluid corpuscles similar in all respects to those by which the atoms were scattered, except in having a stronger tendency or desire to attach themselves to atoms than these have, and except, also, in being able to co-operate with each other to draw atoms together, instead of merely competing with each other for the possession of the atoms, as the corpuscles of the weak kind do.

The corpuscles, being fluid in constitution and amœboid in form, are able to throw out pseudopodia or tentacles from any part of the body: and by the pseudopodia are able to lay hold of atoms or of each other; and to unite with each other by forming joints of the suture kind, in which the pseudopodia are interlocked with each other, as the processes on the bony plates of the skull are interlocked with each other in sutures; or, to take a more familiar instance, as the bristles in two brushes get interlocked when the brushes are brought together forcibly.

The joints thus formed can be opened at once, and the corpuscles can at once separate by simply retracting their interlocked pseudopodia.

The corpuscles, being fluid in constitution, are able to assume all the fluid forms, namely, a pool, or resting or compact form; a stream, or moving form, in which they are elongated; a film, or

flattened form; and, lastly, a wave form, by passing from the pool form to an elongated form, and then back again to the pool form, thus making an excursion to and fro, or by passing from the pool form into the film or flattened form, and back again to the pool form.

The corpuscles, being conceived to be exceedingly subtle in composition, are able to execute these movements with exceeding rapidity when unresisted.

The stream form, then, is the form by which atoms are transported, after the same manner as grains of sand or silt are transported by streams and currents of water.

The film form is the form by which atoms are united together in chemical union, and molecules are united together by cohesion. In this form the fluid corpuscles spread out between atoms and draw and bind them together, as a drop of water spreads out, as we have seen at p. 92, between two plates of glass, and draws and binds them together. In chemical union and cohesion the operation takes place between atoms which are so close together that the intervals between them are to us insensible.

The pool form is the form in which atoms are collected when brought in by streams, as grains of sand and particles of silt are collected at the bottoms of pools in our streams.

When atoms are thus collected in pools, such of

them as drop or fall into the right position for molecule building are bound together in the form of molecules by the corpuscles which spread out between them.

The formation of streams and films is, according to our view, rendered possible in space filled quite full, without interstices, with atoms and fluid corpuscles by the facts that there are two kinds of fluid corpuscles in space—one weak and the other strong; and that the corpuscles of the weak kind were, as shown by the Kinetic Theory of Gases, the first to get possession of the atoms. The weak fluid corpuscles are unable to prevent the intrusion of the strong fluid corpuscles, which, holding together and co-operating with each other, set up a circulation in the two fluids by moving upon the atoms in the stream form after dislodging weak corpuscles and driving them out under pressure, in the form of streams, to take the place vacated in space by themselves as they move in. Hence each stream of strong corpuscles which moves in gives rise to a similar stream of weak corpuscles moving out, and thus sets up circulation in the two fluids.

The weak corpuscles are unable, too, to prevent the further operations of the strong corpuscles as they spread themselves out between the atoms in the film form and draw the atoms together, dislodging the weak corpuscles, as a drop of water spreads out between two plates of glass and draws them together,

dislodging the weak fluid air which previously resided between the two plates of glass.

In fact, with a distribution of atoms at minute intervals throughout space, such as that which the Kinetic Theory of Gases shows us, as we have seen at p. 98, and with strong corpuscles between all the atoms spreading out between them, and drawing atom to atom by dislodging weak corpuscles, we have universal gravitation.

And, moreover, we have an explanation of gravitation, the sufficiency of which can be demonstrated experimentally in a way every one can see and understand, by the action of a drop of water between two clean plates of glass. It is the presence of two fluids, namely, air and water—air weak and unable to resist dislodgment, and water strong—which enables two plates of glass, or any number of plates of glass, to be drawn together, provided that the distances between them all are suitable for the operation of drops of water acting simultaneously upon all pairs of opposite surfaces. So, too, we conclude that the presence of two fluids everywhere between atoms will account for universal gravitation, provided that one of the fluids is weak and unable to resist dislodgment, and the other is strong, and provided also that the intervals between the atoms are not too large for the operations of the strong fluid.

It may be well to point out that, according to this view, the strong corpuscles are excited to activity

by the atoms, and it seems quite natural, therefore, that large atoms should produce greater excitement than small ones, or in other words, that gravitation should be proportional to mass.

According to this view also, distance means resistance, and an increase in distance means increase of resistance, and therefore a diminution in the activity of those who have to overcome the resistance. It would therefore apparently be well in keeping with this explanation to find gravitation inversely proportional to distance. The fact that gravitation is in reality not inversely proportional to distance, but to the square of the distance, seems to point to a spherical arrangement of corpuscles as prevailing over the surfaces of atoms.

Thus we can, as we conceive, put a simple explanation of gravitation within the reach of all, and, moreover, an explanation which accords apparently with Newton's ideas, for it is reached, as we have already seen, by Newton's Agents in Nature.

We are able also, as we conceive, to put within the reach of all an explanation of the process of chemical affinity or chemical union of atoms to form molecules. For in the chemical union of atoms to form molecules in the shape of groups of atoms we have, according to our explanation, the experiment, in which solid glass plates are drawn together by drops of water, performed with solid atoms with flat

places instead of glass plates and by a subtle fluid ether instead of by the gross fluid water.

It will be remembered that we have already, at p. 59, arrived, from the facts shown by the Periodic System of chemistry, at the conclusion that atoms have been derived from perfectly spherical bodies, which have been altered by having flat places made upon their surfaces by cutting down the surface, so as to make chipped spheres in the case of metalloïd atoms, and by building up the surface, so as to make flat-topped prominences, in the case of metal atoms.

We have come to the conclusion that some atoms have one flat place only, others have two only, others have three, and others again have four.

Hence we can see from the experiment with the glass plates that if an atom has only one flat place one other atom and one only can be united to it, provided that there is not room for more than one atom on the one flat place. If, however, it has two flat places, then two other atoms can be united to it, and two kinds of molecules can be formed with it, namely, one kind in which one other atom only is united to it and its second flat place is left unoccupied; and another kind in which two other atoms are united to it.

If it has three flat places, then three other atoms can be united to it.

And if it has four flat places, then four other atoms can be united to it, and, also, four kinds of molecules can be made with it, namely, one kind in which it has only one other atom united to it and three flat places unoccupied; a second kind in which it has two other atoms united to it; a third kind in which it has three other atoms; and a fourth kind in which it has four other atoms. In this way we can understand how it is that carbon, which, according to our conclusion, has four flat places, takes one atom of oxygen only in molecules of carbon monoxide, and takes two atoms of oxygen in molecules of carbon dioxide, while it takes four atoms of hydrogen in molecules of marsh gas.

In this way, then, we see that the experiment with the glass plates shows us that a fluid may, with atoms in the forms we have obtained, be able to build up simple molecules, consisting of two kinds of atoms, with the precision and regularity which actually obtain in nature, as chemistry shows. And when simple molecules have been built up, then, in the same way, complex molecules, consisting of two or more simple molecules united together, may be built up; since some of the simple molecules may have vacant places at which other molecules with vacant places can be united to them. For example, the carbon dioxide molecule has two vacant places on its carbon atom and one vacant

place on each of its two oxygen atoms, and thus four vacant flat places in all; and thus, as pointed out already at p. 73, is specially fitted for the formation of complex molecules.

Since molecules can only be taken on at vacant flat places it follows, as already pointed out at p. 72, that complex molecules will be built up with the same regularity and precision as obtain in the building of simple molecules.

Hence a fluid may supply a way of getting molecules of all kinds, whether simple or complex, built up with regularity and precision: and since the same fluid which builds up atoms into molecules may also, as shown by our experiment with glass plates, and by the phenomena of *water of crystallisation*, serve to build up molecules into masses in which the molecules are connected by interlocking atoms kept in position by fluid attraction; our explanation of attraction may therefore give us a clear explanation of cohesion also.

We may remark in passing that in the water by which the glass plates are drawn and bound together in the experiment we have, according to our view, the fluid so clogged with a load of atoms, and thus hampered in its movements, that we are able to follow its movements; but, nevertheless, we have before us the same fluid as that by which atoms are drawn and bound together in the formation of molecules.

Hence we are able with our explanation to connect together in one form of fluid attraction the processes of gravitation, chemical union, and cohesion. With it we can get solid atoms brought together by gravitation and built up into molecules by chemical union; and then when enough molecules have been built up, we can get molecules, when they catch against each other by the projecting atoms in some of the molecules getting interlocked or caught in the intervals between the atoms in other molecules, bound together by the fluid, and thus built up by cohesion into masses or bodies.

Since fluids, as we know from the cases of our streams and rivers, can transport bodies, we can have no difficulty, with our explanation, in understanding the proper motion of systems of bodies such as the planets and solar systems in the heavens. For this we simply require currents, such as those with which we are acquainted in molar physics, amplified to a sufficient extent to deal with huge planets and suns in the same way as our streams and currents deal with the small bodies which are carried along by them.

We know that jets and currents when flowing through a resisting medium usually, if not always, follow spiral courses. And if, therefore, one of our solar systems is immersed in and carried along by a vast spiral current, we can understand that it may so happen that the planets in this solar

system will follow spiral paths and will all revolve in the same direction. We can understand also how it may happen that the planets, though all revolving in the same direction, will not all revolve at the same speed; because we know that in a current flowing through a resisting medium the velocity is not the same in all parts of the current.

On the other hand we can, by the operations of the other fluid which drives atoms apart, explain the breaking up or dissociation of molecules by heat or by electrolysis, and thus the possibility of analysing compound molecules into the elementary atoms of which they are composed, and also the possibility of isolating elementary substances. We can explain also the melting of solids, and the vaporisation of liquids, and thus the dissipation of solid bodies in the form of gas or vapour. We can also explain the eruptions which send gaseous and solid masses flying aloft, and thus tend to break up satellites, planets, and suns; and we can explain, too, the centrifugal motion which tends to send satellites flying away out of planetary systems and planetary systems flying away out of solar systems. Hence we can refer the ordinary forms of attraction and repulsion which confront us in the universe to the antagonism between two fluids over the possession of matter. So far, however, we have not dealt with electrical attraction and repulsion.

In the case of electricity we have a two-fluid

theory already in the field, and, in fact, a two-fluid theory of long standing; and thus phenomena which very distinctly point in the direction we are taking.

"In an utterly modified sense," says Principal Oliver Lodge, "we have still a fluid theory of electricity, and a portion of the ideas of the old theories belong to the new theory also. . . . Part also—a less part—of the two-fluid theory, likewise remains true in my present opinion."¹ Now, in the case of electricity we have two kinds of electricity distinctly recognised, and known as positive and negative electricity respectively. And then we have clear evidence that negative electricity is distinguished by the fact of its exercising upon matter a more powerfully condensing action than positive electricity exercises. Professor J. J. Thomson tells us that electrified gas "possesses the remarkable property of producing a fog when admitted into a vessel containing aqueous vapour;"² and then notices that "the particles in the cloud formed by negatively electrified oxygen are larger than those formed by positively electrified oxygen."³

Professor J. J. Thomson also states that "when ultra-violet light falls on a negatively electrified platinum surface, a steam jet in the neighbourhood of the surface shows, by its change of colour, that the steam in it has been condensed . . ."

¹ "Modern Views of Electricity," second edition, p. 27.

² "Discharge of Electricity through Gases," p. 11.

³ *Ibid.*, p. 15.

"but no condensation can be detected when the surfaces are charged with positive electricity."¹ The condensing action of negative electricity is, however, according to our view, shown much more clearly by the well-known fact that in the arc light the point of the carbon of the positive pole wastes away, while the carbon at the negative pole grows by the particles of carbon which pass across to it from the positive pole: also by the equally well-known and analogous fact that when the poles of a battery are of copper wire, the negative pole takes on copper and grows longer, while the positive pole wastes away if both poles are immersed in a solution of sulphate of copper.

Thus we see that negative electricity exhibits activity in the direction of the attraction or condensation of atoms or molecules of matter analogous to the activity in the way of condensing and attracting atoms and molecules of matter which the law of gravitation indicates. While positive electricity, as shown by the wasting away of the carbon at the positive pole of an arc lamp, and of the copper of the positive pole of a battery when its poles are of copper wire immersed in a solution of copper sulphate, exhibits activity in the direction of scattering and dispersing atoms of matter similar in kind to that indicated by the Kinetic Theory of Gases.

¹ "Discharge of Electricity through Gases," p. 74.

We thus get the two kinds of electricity, namely, positive and negative electricity, directly connected with the two kinds of motion revealed by gravitation and by the Kinetic Theory of Gases. We have positive electricity connected with undirected motion tending to scatter atoms by setting them in wild flight in all directions, and negative electricity with directed motion tending to draw atom to atom, and thus bring atoms together.

But according to our conclusions the undirected motion indicated by the Kinetic Theory of Gases can be explained by fluid action analogous to the dispersive action of a liquid when it dissolves a solid mass too small by far to give a saturated solution, and consequently the many molecules of the liquid compete with each other for the possession of the few molecules of the solid.

And, at the same time, the directed motion by which atom is drawn to atom in the case of gravitation and other forms of attraction can also be explained by fluid action analogous to the attraction which drops of water, oil, and other liquids exercise upon clean plates of glass, and upon plates of other kinds when the distance between the plates is less than the depth of a drop, so that both sides of each drop are in contact with plates. We thus get electrical phenomena directly brought into line with our two-fluid theory of the ether.

But fluids have three main forms, namely, the

pool, the *stream*, and the *wave*, and two fluids have eddies or vortices also. And since electricity has three main forms corresponding to the three fluid forms, namely, static or fixed electricity, current electricity, and electrical waves, while magnetism has vortices, we see at once the general applicability of a fluid explanation to the case of electricity.

At all events, we believe that we can easily make its applicability clear.

Taking the case of static electricity, we find in regard to charges of electricity, from Principal Oliver Lodge, that "it is impossible to charge one body alone. Whenever a body is charged positively, some other body is, *ipso facto*, charged negatively."¹

We learn also "that you cannot produce positive electrification without an equal quantity of negative also; that what one body gains of electricity, some other body must lose."

"Now whenever," Principal Oliver Lodge goes on to say, "we perceive that a thing is produced in precisely equal and opposite amounts, so that what one body gains another loses, it is convenient and most simple to consider the thing not as generated in the one body and destroyed in the other, but as simply transferred. *Electricity in this respect behaves just like a substance.*"²

Now it is plain that our views enable us to give

¹ "Modern Views of Electricity," second edition, p. 417.

² *Ibid.*, p. 8.

an explanation of electrification. We have, according to our conclusions, space filled quite full with solid atoms of matter and two incompressible fluids, one of which is stronger than the other and is dislodging the other from its position about the atoms of matter, and is getting possession of the atoms and drawing them together and building up with them molecules, masses, bodies, and systems of bodies; but, at the same time, its operations are steadily and strenuously resisted by the weak fluid, which endeavours as it goes out to carry off atoms of matter along with it, and sometimes succeeds for a time in turning the tables on the strong fluid, and dislodging it and driving it out.

Electrification is then the forcible displacement of a portion of the strong fluid in or about some mass or body, and its replacement by an equal quantity of the weak fluid. We have then a charge of negative electricity in the shape of the portion of the strong fluid so displaced and transferred to some other body, and a charge of positive electricity in the shape of an equal quantity of the weak fluid which replaces the strong fluid. And the charges will remain so long as there is no way open for the return of the strong fluid. As soon, however, as a way is open, the strong fluid will make its way back, and, dislodging the weak fluid, will send it back to the body or bodies from which it came, and all the

electrification will disappear. We can give an illustration of our ideas in regard to electrification with the help of the two fluids, one strong and the other weak, namely, water and air, which exist side by side on the surface of our earth, if we make allowance for the fact that the two fluids we require are both incompressible, while in the case of water and air one of the fluids can be very easily compressed.

Taking, then, with this reservation, water and air as our two fluids, we can look out for a pool of water at a low level and then look out for an empty pool of the same size at a high level. If we then proceed to fill the empty pool at the high level from the pool at the low level we shall have a pool filled with water at a high level and a pool of the same size filled with air at a low level; and thus we shall have raised a quantity of water to a high level by forcibly displacing and transferring it, and brought down an equal quantity of air to a low level. The upper pool has a charge of water corresponding to a charge of negative electricity, and the lower pool has a charge of air corresponding to a charge of positive electricity. The two pools will remain charged if the bottom and sides of the higher pool remain water-tight and the water does not evaporate, and provided also that no water from any other source finds its way into the lower pool. But as soon as a way is opened for the water in the upper pool to pass down to the lower pool, it will

find its way down, and both pools will lose their charges. The water will go down to the lower pool, and the air will go up to the upper pool.

If the upper pool is covered over with an air-tight roof, and a pipe is laid from the higher pool down to the lower, we shall have a stream of water flowing down the pipe, and side by side with it a stream of air flowing up the pipe.

We shall now have from the water and the air not only an illustration of what occurs, according to our view, in electrification, but also an illustration of what occurs with electrical currents also. For, according to our view, a current of electricity consists of a stream of the strong fluid in one direction with a stream of the weak fluid in the opposite direction, as shown in a very marked way by electrolysis, which can be well explained by our streams of water and air.

For suppose that at some point in the pipe an accumulation of sand and dust has occurred; and suppose that the stream of water does not fill the pipe: we may have then the stream of water washing away the sand from one side of the heap and carrying it down the pipe, and the stream of air passing over the other side of the heap and picking up the dust and carrying it along with it up the pipe; we may have a procession of light dust particles in one direction, and a procession of heavy sand particles in the opposite direction.

And we shall have the air current exercising a selective action in picking up the dust particles and other particles which can easily be carried, and leaving the heavy grains of sand to be carried by the water. But we have in electrolysis similar processions of atoms in opposite directions.

"The atoms," says Principal Oliver Lodge, "may be said to be driven along by their electric charges. . . . Now notice the fact of the two opposite processions. It is impossible to get one kind of ion liberated at one electrode without having a precisely equivalent quantity of the opposite ion liberated or deposited, or otherwise appearing, at the other electrode; and this fact may be expressed by saying that it is impossible to have a procession of positive atoms through a liquid without a corresponding procession of negative ones. In other words, an electric current in a liquid necessarily consists of a flow of positive electricity in one direction combined with a flow of negative electricity in the opposite direction. And if this is thus proved to occur in a liquid, why should it not occur everywhere?

"Another case is known where an electric current certainly consists of two opposite streams of electricity, viz. the case of the Holtz machine."¹

While Professor J. J. Thomson remarks, in regard to "the conductivity conferred on gases by light, Röntgen rays, and heat," that "the phenomena can

¹ "Modern Views of Electricity," p. 92.

be explained on the supposition that the electricity gets through the gas by the movement of oppositely charged ions through the gas, the process being similar to that by which electricity is carried through an electrolyte. The passage of sparks through a gas furnishes us with additional evidence in favour of this view." ¹

Again, in regard to certain experiments in connection with the electrolysis of gases, Professor J. J. Thomson remarks that "these experiments suggest that the separation of two gases, A and B, by the discharge, is due to the decomposition by the discharge of a chemical compound formed of A and B, in which the A atoms have a charge of electricity of one sign, the B atoms a charge of electricity of the opposite sign, and that these charged atoms, under the influence of the electromotive force in the tube, travel in opposite directions." ²

Hence it is plain that the phenomena of electrolysis, both in the case of liquids and in the case of gases, furnish us with evidence that in a current of electricity there is a flow of negative electricity in one direction side by side with a flow of positive electricity in the opposite direction, analogous to the flow in our experiment of a stream of water in one direction, side by side with a stream of air flowing in the opposite direction. And it is also

¹ "Discharge of Electricity through Gases," p. 121.

² *Ibid.*, p. 136.

plain that in electrolysis there are two processions of atoms in opposite directions corresponding to the two processions of dust particles and grains of sand moving in opposite directions in our experiment, with which the dust particles go in the air current and the grains of sand in the stream of water.

Moreover, we find in the case of electrolysis the same evidence of selective action as is shown by the current of air and stream of water.

We have seen that currents of air may pick up and transport dust, and other light and easily carried particles, and leave large grains of sand to be carried down by streams of water. In the case of electrolysis we find that when binary compounds containing hydrogen are electrolysed, the light hydrogen atoms, corresponding to dust particles, go off, as a rule, at the negative pole, and are thus transported, as we may suppose, by the current of positive electricity, while the other, and less easily carried atoms, go off at the positive pole, and are thus transported by the current of negative electricity.

It is, however, somewhat puzzling to find that not only do light hydrogen atoms go off in electrolysis at the negative pole, but heavy metal atoms also go off at the negative pole.

It seems possible that the explanation of this may be that metal atoms go off singly, while metalloid atoms unite and form diatomic molecules, as is their wont when free, and that single metal atoms are

more easily transported than diatomic metalloid molecules.

On the whole, we conclude that in the two processions of atoms which characterise electrolytical phenomena, the procession in the flow of positive electricity carries the atoms or molecules which are most easily transported, while the flow of negative electricity carries off atoms or molecules which are less easily carried: and that in this respect currents of positive electricity behave in the same way as air currents behave when they pick up and carry off, not only minute dust particles, but also larger things, such as leaves and bits of straw, which are easily carried, and at the same time leave behind grit and coarse grains of sand, which are easily carried by streams of water.

We know that a stream of water may sweep away obstruction after obstruction, and go on with undiminished strength; so, too, we find that an electric current may break up electrolyte after electrolyte if it meets with them, and go on with undiminished strength. Our conclusion, therefore, is that a current of electricity is analogous to the case of a stream of water flowing down with a return stream of dislodged air flowing in the opposite direction; or, in other words, consists of a current in one fluid with a return current in another fluid dislodged and displaced: and thus that for the production of electric currents, the presence of two fluids is necessary.

We may have, as we know, one-fluid currents. We may have ocean currents, currents of water with return currents of water, or currents of water circulating in water; and we may have currents of air circulating in air, as in the case of cyclones.

These, according to our view, are not analogous to electrical action, but to mechanical action, with which action and reaction are equal and opposite.

These will serve to explain to us the connection between electricity and mechanics, and also the difference between electrical and mechanical action.

Now we can connect electricity with mechanical action by means of frictional electricity. When two bodies are rubbed together we know that the friction which ensues is due to the roughness of the surfaces thus rubbed together, and arises from the minute projections on the surface of one of the bodies either catching against minute projections on, or catching in minute pits or depressions in the surface of the other body.

And if, then, one of the bodies is softer than the other, and if at the same time the rubbing takes place in one direction only, it is plain that the result of rubbing the two bodies together will be that the surface of the softer body will be compressed by the projections on the harder body as they press against the projections on or sides of the pits in the surface of the softer body. As the result of this compression, the surface of the softer body will receive a

charge of the strong fluid by which molecules are condensed into masses. At the same time the projections on the surface of the harder body will by the act of compressing the softer body be subjected to a strain tending to wrench them off, and therefore extend and separate them; and by this extension will receive a charge of the weak fluid by which molecules are separated or driven apart. We can thus understand how it is that when a glass rod is rubbed by a silk handkerchief the hard glass surface receives a charge of positive electricity, and the handkerchief with its soft silk fibres receives a charge of negative electricity. And we can also understand how it is that when sealing-wax is rubbed by a piece of flannel, the soft, easily melted wax receives a charge of negative electricity, while the flannel with its hard fibres of wool receives a charge of positive electricity. And again we can understand how it is that when an insulated disc of glass is rubbed against an insulated disc of brass and then separated from it, the hard glass disc is found to have a charge of positive electricity, while the soft brass disc has a charge of negative electricity.

We can also readily understand how it is that a wire from the soft body in a frictional electric machine will give a current of negative electricity, and therefore a current of the same kind as a wire from the zinc plate of a galvanic battery gives; and how a wire from the hard body in a frictional electric

machine conveys a current of positive electricity, and thus a current of the same kind as the wire from the copper plate of a galvanic battery conveys.

When a liquid combines with a hard solid to form a soft solid it is manifest that the resulting soft solid represents a mass in the intermediate state—that is to say, it represents a mass in a state intermediate between the condensed state of the hard solid body and the uncondensed state of the liquid; in fact, the hard solid body loses part of the strong fluid by which in the form of cohesion its molecules were firmly bound together, and the liquid loses part of the weak fluid by which its molecules were kept in a state of agitation.

It is also clear that the molecules in the hard body will have to be loosened and thus the strong fluid which binds them together will have to be dislodged to enable combination to take place.

It is also plain that for the dislodgment of the strong fluid there must be an influx of the weak fluid sufficient to give it the superiority by numerical strength.

It is plain also that the necessary influx of the weak fluid must come from surrounding bodies; and that the efflux of the strong fluid dislodged by the influx of the weak fluid will pass to the surrounding bodies which supply the influx. Hence there will be an influx of the weak fluid, which drives atoms and molecules apart, and side by side with this influx there will be an efflux of

the strong fluid, by which atoms and molecules are condensed and bound together.

If one of these surrounding bodies is a metal plate which conducts the two fluids freely, and if this metal plate is connected by a wire which conducts the fluids freely to a hard body which combines with the liquid; then we can readily understand how there may be a flow of the weak fluid from the metal plate to the hard body along the wire, and a flow of the strong fluid from the hard body to the metal plate, also along the wire. If the metal plate is a plate of copper, and the hard body a plate of zinc, and the liquid which combines with the zinc sulphuric acid so diluted that it will not combine readily with the zinc unless the molecules of zinc are loosened; and if the copper and zinc plates are connected at one end by a copper wire which conducts the two fluids freely, and at the other end by the dilute sulphuric acid: a current of galvanic electricity may, according to our view, flow along the wire in the form of a flow of the weak fluid, representing positive electricity from the copper to the zinc, and a flow of the strong fluid representing negative electricity in the opposite direction from the zinc to the copper.

But since the strong fluid cannot pass without dislodging a portion of the weak fluid, and the weak fluid cannot pass without dislodging a portion of the strong fluid, we can easily see, with our explanation,

that a current of positive electricity may consist of a flow of positive electricity in one direction, with a flow of negative electricity, partly side by side and partly at a distance, in the opposite direction, but so that, at the point immediately under observation, there is an excess of positive electricity flowing. Similarly, a current of negative electricity may consist of a flow of negative electricity in excess in one direction, side by side with a flow of positive electricity in the opposite direction.

Both currents may therefore show phenomena of attraction from the condensing action of the strong fluid, and both may show repulsion from the separating or expansive action of the weak fluid. The difference between them, under such circumstances, will be that the current of negative electricity will exhibit greater condensing effects than the current of positive electricity exhibits, and the current of positive electricity more repulsive or heating effects than the current of negative electricity exhibits.

In this connection we may point to the fact, already noticed at p. 148, that Professor J. J. Thomson finds that electrified gas possesses "the remarkable property of producing a fog when admitted into a vessel containing aqueous vapour,"¹ and also that "the appearance of the cloud, and the size of its particles, depend upon the sign of the electrification; thus the particles in the cloud formed by

¹ "Discharge of Electricity through Gases," p. 11.

negatively electrified oxygen are larger than those formed by positively electrified oxygen.”¹

For this seems to show clearly that positive and negative electricity both exercise an attractive or condensing action upon molecules of matter, but not with equal effect, since negative electricity forms larger particles, and therefore, as we may conclude, acts more powerfully than positive electricity.

It thus appears that a two-fluid theory of energy will explain not only the Kinetic Theory of Gases and gravitation, together with chemical affinity and cohesion, but also electrical and mechanical action. With it we have an Ether composed of two fluids—a two-fluid ether, which in the presence of matter gives us, as we have seen, a fluid explanation of the Kinetic Theory of Gases, a fluid explanation of gravitation, chemical affinity, and cohesion; and a two-fluid explanation of electricity.

And since a two-fluid ether may give a vibrating medium in the presence of matter—for if one fluid displaces atoms of matter the other will resist, and under certain circumstances may force the atoms back into their places—we can plainly get from it a fluid explanation of sound by means of vibrations large enough to displace atoms of matter, and carry them bodily backwards and forwards. And since Newton himself has pointed out, in effect, that an undulatory theory of light is only admissible

¹ “Discharge of Electricity through Gases,” p. 15.

on the assumption "that there are in all space two ethereal vibrating mediums, and that the vibrations of one of them constitute light,"¹ we can bring forward Newton's authority in support of the view that our two-fluid ether will give a fluid explanation of the undulatory theory of light. According to this view, light waves are waves which, unlike sound waves, are not large enough to displace atoms of matter, but are waves like ocean waves, due to the interaction of two fluids at their surfaces of contact. In the case of ocean waves we may have waves due to the interaction of the two fluids, air and water, at their surfaces of contact, and waves which are propagated by a disturbance at right angles to the direction in which the waves travel over the surfaces of oceans, seas, and creeks. So, too, we conclude that on the surfaces of fluid pools which form envelopes about atoms of matter, the interaction of the strong and weak fluids of which our two-fluid ether is made up may give rise to waves propagated by disturbances at right angles to the direction in which the waves travel over pools and along streams.

In the case of heat, we know that a fluid explanation of heat has long been current. "From the dawn of science," we are told, "till the close of last century two rival hypotheses had been entertained regarding the nature of heat. . . . One that heat consisted of a subtle elastic fluid permeating

¹ "Opticks," third edition, p. 339.

through the pores or interstices among the particles of matter, like water in a sponge ; the other that it was an intestine commotion among the particles or molecules of matter. In the year 1799, Davy, in his first published work, entitled 'An Essay on Heat, Light, and Combinations of Light,' conclusively overthrew the former of these hypotheses, and gave good reason for accepting as true the latter, by his celebrated experiment of converting ice into water by rubbing two pieces of ice together without communicating any heat from surrounding matter. . . .

"Joule's great experiments, from 1840 to 1849 . . . recalled attention to Davy and Rumford's doctrine regarding the nature of heat, and supplied several fresh proofs, each, like Davy's, absolutely in itself complete and cogent, that heat is not a material substance. . . . After several years of trials, he was led to prefer to all others the direct method of simply stirring a quantity of water by a paddle, and measuring the quantity of heat produced by a measured quantity of work ; and this method he has accordingly used in all his experiments for the purpose of determining the 'dynamical equivalent' of heat from the year 1845 to the present time." ¹

Thus we have a clear statement of the old fluid explanation of heat, and also a clear statement to the effect that it has been rejected on the strength of the results of Davy's and Joule's experiments.

¹ Article, *Heat*, "Encyclopædia Britannica," ninth edition.

On looking, however, more closely into these experiments we find that all are open, not only to an entirely different interpretation, but also to the objection that they neglected to take account of the fact that a vast store of latent heat existed in the air, which was in contact alike with the pieces of ice which Davy rubbed together, and with the water which was stirred by Joule's paddle, and could be developed by the methods employed in Davy's and Joule's experiments. It seems strange that Joule overlooked the existence of latent heat in the air, because he recognised that air could be heated simply by compressing it, and that the heat evolved from the air so condensed would raise the temperature of substances in contact with it. For Joule remarks that, in a paper "read before the Royal Society in 1844, I endeavoured to show that the heat absorbed and evolved by the rarefaction and condensation of air is proportional to the force evolved and absorbed in those operations."¹

If heat be an incompressible fluid, and latent heat in air or other gases be a quantity of that fluid collected in the interstices between the air molecules, as water in a wetted sponge; then it is plain that if a quantity of air is compressed a quantity of heat will be evolved, for the same reason as a quantity of water may be driven out from a sponge if a wetted sponge is squeezed; or if, on the other hand,

¹ "Philosophical Transactions," 1850, p. 63.

the air after being compressed is expanded, a like quantity of heat will be absorbed, for the same reason that if the squeezed sponge is expanded in water to its former size it will take up the same quantity of water as was given out of it when it was squeezed.

It is plain, therefore, that the results in Joule's paper read before the Royal Society in 1844, which showed, as we have seen above, that the "heat absorbed and evolved by the rarefaction and condensation of air is proportional to the force evolved and absorbed in those operations," confirmed, as far as they went, the correctness of the ancient hypothesis that heat is a "fluid permeating through the . . . interstices among the particles of matter, like water in a sponge," provided that heat is taken to be an incompressible fluid instead of an elastic fluid, as the old view made it.

Besides this, however, Joule also noticed that sea water is warmed by storms.¹ But he does not seem to have connected this fact with his experiments by which he showed that heat is evolved when air is condensed. And yet it is perfectly plain that the foam which whitens the crest of every wave that breaks consists of air bubbles, each of which represents a mass of air under compression by the sea water, and therefore condensed and evolving heat to the water. It is quite clear, therefore, that Joule's results, by which he showed that heat was

¹ "Philosophical Transactions," 1850, p. 63.

evolved when air was condensed, supplied a full and sufficient explanation of the fact that sea water is warmed in a storm.

But the point is that when Joule with his after experiments stirred water with a paddle, he was in effect churning up air and water together, and thereby forcing air bubbles into the water, and thus doing in another way just what storms do to sea water.

It seems plain, therefore, that Joule's results, which showed that heat is evolved when air is condensed, afforded an explanation not only of the heating effect of a storm upon sea water, but also an explanation of Joule's other results by which he showed that water was heated by the act of stirring it with a paddle.

From Joule's own account, as given in his paper on the Mechanical Equivalent of Heat,¹ we learn that he used "a brass paddle-wheel furnished with eight sets of revolving arms . . . working between four sets of stationary vanes," and that he had a copper vessel "into which the revolving apparatus was firmly fitted," with a copper lid which "could be screwed perfectly water-tight to the flange of the copper vessel. . . ."

He goes on to say that in "the lid there were two necks, *a*, *b*, the former for the axis to revolve in without touching, the latter for the insertion of the thermometer. . . ."

¹ "Philosophical Transactions," 1850, p. 61.

He adds that a brass stopper "was placed in the neck, *b*, . . . for the purpose of preventing the contact of air with the water as much as possible."

But apparently there was no arrangement for closing the air way at the neck, *a*, in which the axis of the paddle revolved "without touching." Indeed, the very statement that a stopper was used in the neck, *b*, in order to prevent the contact of air with the water as much as possible, implies that the copper vessel was not air-tight. Hence it would seem that Joule's apparatus was well adapted for aerating water by churning up air and water together.

At all events it is well known that water can be aerated by shaking up a mixture of air and water together in a closed vessel. It is equally clear that when water is aerated in either of these ways the air is forced into the water under pressure.

We have seen above that Joule's results, by which it was shown that heat is evolved from air when it is condensed, confirm as far as they go the correctness of the ancient view that heat is a fluid.

We now perceive that the other experiments, by which Joule showed that water is heated when stirred in a closed vessel, reach the same result in another way, and therefore, also, as far as they go, confirm the correctness of the ancient view that heat is a fluid.

In the case of Davy's celebrated experiment,

on which, as we have seen, modern views rely to support their rejection of the ancient view that heat is a fluid, we have already shown in the "Advance of Knowledge," at page 105, that the first effect of rubbing two pieces of ice together must necessarily be to fill up the minute pits and depressions in the rubbed surface of the two blocks of ice with a mixture of air and ice-dust. When the pits and depressions have been filled with the mixture, the after-effect may be to compress the mixture of ice-dust and air more and more closely into the pits and depressions, thereby condensing the air which forms part of the mixture. And since Joule showed, as we have seen, that the effect of condensing air is to cause an evolution of heat from the air so condensed, the final effect may be the melting of the ice-dust by the heat evolved from the air imprisoned amongst the particles of ice-dust and compressed.

The fact that ice is bulk for bulk lighter than water, and therefore being very open in structure, necessarily has many pits and interstices in which air can be imprisoned, is, of course, of much importance in connection with our interpretation of Davy's celebrated experiment. At all events, Davy's experiment, when viewed in this way, confirms the correctness of the ancient view in regard to the fluidity of heat instead of "conclusively" overthrowing it as it was held to do.

However, although we thus recognise the fact that Davy's and Joule's experiments do not conclusively overthrow the ancient view in regard to the fluidity of heat, we do not for our part accept the ancient view in regard to the fluidity of heat, at all events in its entirety. Our view is that heat, like electricity, is not a fluid, but a fluid effect in the same way as gravitation, chemical affinity, and cohesion are, according to our view, fluid effects. In fact, according to our view, heat is a dispersive or scattering effect upon atoms due to the activity of one of the two fluids which, when moving side by side in opposite directions, together produce the effect which we call a current of electricity. According to this view heat is latent when the activity of a part of the fluid is confined to a particular set of atoms, so that the fluid is entirely occupied in dealing with them, and produces no effect on the atoms of surrounding masses.

Heat becomes sensible when a part of the fluid is dislodged from its position about the atoms in some particular set of atoms to which its activity was before confined, and passing out, presses upon the atoms of surrounding masses and thereby increases the intestine commotion amongst them by tending to disperse them.

If heat is a fluid effect of a dispersive or scattering kind, it is, of course, an effect of the weak fluid which imparts to atoms of matter the wild,

chaotic motion which, as the Kinetic Theory of Gases shows, sets them flying blindly in all directions independently of each other and thus separates them and keeps them apart. In fact, our explanation not only substantiates the correctness in a modified form of the ancient view of heat by making heat to be not a fluid, but the effect of a fluid permeating through the pores or interstices among the particles or molecules of matter, like water in a sponge, but also substantiates the correctness of the modern view that heat is "an intestine commotion amongst the particles or molecules of matter." For "intestine commotion among particles or molecules of matter" can, as we have shown, be referred to fluid dispersive action.

Thus we have got an Ether composed of two fluids which will, in the presence of atoms of matter, through antagonism kindled by the tendency in both fluids to take possession of atoms of matter, give us a fluid explanation not only of the Kinetic Theory of Gases but also of all physical processes and all physical phenomena. Gravitation, chemical affinity, cohesion, centripetal motion, negative electricity, heat, dissociation, centrifugal motion, and positive electricity can all be obtained from this ether. Inertia, too, can also be obtained, since it represents the resistance to dislodgment offered by both of the fluids alike and the delay in starting all

operations which such resistance causes. The two-fluid ether gives us also sound and light, condensation and solidification, expansion, and vaporisation.

But if we can see fluid action in all physical forms of attraction and repulsion or dispersion, and also in all electrical forms of attraction and repulsion, we can also plainly see fluid action in mechanics. In fact the only real explanation within our reach of the composition and resolution of forces is manifestly a fluid explanation. Converging streams or currents will yield a single resultant stream or current, and a single stream or current can be resolved into two or more diverging streams, just as a single resultant force can be composed of two or more converging forces, or a single force can be resolved into two or more diverging forces in the composition and resolution of forces.

Retardation can be explained with the two fluids. For a body partly immersed in two streams or currents flowing in opposite directions may be carried along by one of them, provided that it slips through the other, as a ship running before a strong breeze can slip through an ocean current flowing in the opposite direction to that in which the breeze is blowing. The ship is driven along by the breeze, but nevertheless it is retarded by the current.

If the breeze gets stronger, while the current remains the same, the ship will run faster, or in other words, its speed will be accelerated. If the breeze gets still stronger the ship will run faster still before it; thus the speed of the ship will be still further accelerated.

If a cask is floating in a current it may remain stationary if the wind and the water act with equal strength upon it from opposite directions; or it may revolve and thus move with both streams without advancing in either.

We know that a stream which is trickling down from pool to pool may be swollen into a torrent if it is joined by other streams flowing strongly. As the stream swells by successive additions its velocity will increase. The velocity of any body that happened to be floating down the stream when it was trickling from pool to pool will increase as the stream swells, or in other words, the velocity of the body will be accelerated.

With fluids we may have flooded streams as well as streams very low.

A stream may be increased by turning other streams into it, or reduced by tapping it or diverting part of its supply into other channels. It may also be concentrated by narrowing its channel, or it may be allowed to spread out and thus weakened by widening its channel. A stream may get round resistance which it cannot overcome directly by

bending round in some direction where there is less resistance, and a current may get past resistance by flowing spirally.

To one or other of these ways of dealing with streams or floods so as to make them serviceable or manageable all devices for obtaining mechanical advantage may be referred ; that is to say, they are ways of flooding or tapping or draining off, or are ways of concentrating or spreading, or are ways of diverting opposition or getting round obstacles.

It will thus be seen that, according to our view, the universe is a vast ocean or abyss filled with an ether composed of two forms of energy in the shape of two fluids, and matter composed of inactive atoms unsuited for building purposes by reason of their form, and active or valent atoms which have been prepared from inactive atoms by shaping them so as to fit them for building purposes. At the same time, the atoms are the battle-ground of the two fluids which together make up the ether. The ether is traversed and kept in constant agitation by the streams, floods, and waves to which the conflict gives rise, as the strong fluid flows in while the weak fluid, dislodged and dispossessed, flows out ; and we have tried to show that, with an ether made up of two fluids in antagonism over the possession of atoms of matter, the main facts connected with all phenomena in the inorganic universe can

be explained, whether they are of the physical, electrical, or mechanical order.

In the next chapter we have to make an endeavour to show that phenomena connected with the organic world—the world of organisms—can be explained in the same way.

CHAPTER VII

THE LAST STAGE

WE have endeavoured in the preceding chapters to show that the universe is the scene of a conflict between two fluids, or rather between two hosts of minute fluid corpuscles.

We have seen that the conflict is over the possession of atoms of matter, consisting to a great extent of atoms, which have been dressed or shaped for building purposes.

We have found that both of these fluids have a strong affinity for atoms of matter, which leads the corpuscles, of which the fluids are made up, to make for and attach themselves to atoms of matter whenever possible; but, at the same time, we have seen that one of the fluids has a stronger affinity for atoms than the other.

We have found that the weaker of the two fluids was the first to get possession of the atoms of matter, but did no building work with them. Instead of putting up buildings with the atoms, the corpuscles, of which the weak fluid is made up, simply competed with each other for the possession of the

atoms of matter, those which had hold of atoms clinging to them, and endeavouring to keep possession, and the remainder, the vast majority, which had not got possession, pressing in upon these and endeavouring to oust them. Thus by mad competition the atoms which had been dressed or shaped with the greatest accuracy, and fitted for the erection of buildings of the loveliest forms, of which we can get but a faint conception from the loveliest things we know amongst gems and flowers and birds, were scattered throughout the tract of space occupied by the weak fluid and kept in the state of wild commotion which the Kinetic Theory of Gases exhibits.

When things were in this chaotic state, the hosts of strong fluid corpuscles occupying an adjoining tract of space were, according to our conclusions, aroused to activity, and came pouring in streams upon the atoms, dislodging the corpuscles of the weak fluid and driving them out in streams into the tracts of space vacated by themselves in their advance.

Co-operating with each other, and holding together, and making always for the nearest atom, and thus following the lines of least resistance, and following each other by the ways opened up by those in front, the corpuscles of the strong fluid advanced in perfect regularity and in good order, in strong contrast with the wild movements of the host of madly competing corpuscles of the weak fluid.

We have seen in the preceding chapters how, co-operating thus with each other, and advancing with regularity and in good order, the corpuscles of the strong fluid, while compelling the wild corpuscles of the weak fluid to move out in like order and regularity by the ways left open for them, took hold of the atoms, and then proceeded to collect them together and bind them together when they had been brought in. We have seen how in this way atom was bound to atom to form molecules, molecule to molecule to form masses, mass to mass to form bodies, body to body to form systems of planets and satellites, or planetary systems, and planetary system to planetary system to form solar systems.

The stage before us now is the ingathering of solar systems, a condensation, in fact, of solar systems, and thus a stage in which solar systems are being brought together, each by its proper motion through space. That such condensation is actually taking place seems to be shown incontestably by the existence of the Milky Way.

Sir John Herschel tells us that the Milky Way, "when examined through powerful telescopes, is found (wonderful to relate!) *to consist entirely of stars scattered by millions, like glittering dust on the black ground of the general heavens.*"¹

He tells us also that if we take account of the

¹ "Outlines of Astronomy," ninth edition, p. 196.

whole amount of stars visible to the naked eye "we shall perceive a great increase of number as we approach the borders of the Milky Way. And when we come to telescopic magnitudes, we find them crowded beyond imagination, along the extent of that circle, and of the branches which it sends off from it. . . . These phenomena agree with the supposition that the stars of our firmament, instead of being scattered in all directions indifferently through space, form a stratum of which the thickness is small, in comparison with its length and breadth; and in which the earth occupies a place somewhere about the middle of its thickness."¹

The Milky Way thus shows us that the same condensation has taken place among the stars as has taken place among the molecules which have been collected into masses. Thus, also, it shows us that a continuous process of condensation has been at work in the universe by a succession of stages, beginning with the stage in which, as we have seen, atom was drawn to atom to form molecules, then molecules were drawn together to form masses, then masses were drawn together to form bodies, then bodies were drawn together to form planetary and solar systems, and ending with the stage in which solar systems are being drawn together to form a Milky Way—a condensation of suns. And we conclude that the work of condensation is still going on

¹ "Outlines of Astronomy," ninth edition, p. 568.

amongst the stars, because astronomers find that our solar system has a proper motion in space.

We are not concerned here, however, with any attempt to follow exactly the motion, either of our own or of any other solar system, during this stage, in view more especially of the fact, that, though the main body of the stars may be moving in, there may be retrograde motion amongst some under the action of the weak fluid which, when concentrated on certain points, is able to break up molecules, masses, bodies, and perhaps even to break up some of the solar systems for a time, or at all events to turn some of them back on their way towards condensation.

It is enough for our purpose to point out that streams and currents can transport bodies, and that large streams and currents can transport large bodies, though small streams and currents can only transport small bodies; and, therefore, that there is no reason to doubt that the largest bodies, and therefore planets and suns, can be transported if streams or currents on a sufficiently large scale are available.

If, in addition to this point, we take into consideration the fact that with fluid motion we have not only eddies and vortices, but also spiral streams and currents; and also the fact that bodies in an eddy revolve, and when drifting down spiral streams or currents necessarily follow spiral paths through space; and also remember that the fact that our

solar system has a proper motion shows that our earth and the other planets of our system follow spiral paths, and do not move in closed curves round the sun: we shall, in view of all the facts before us, see that there are good grounds for the conclusion that our sun moves through space with its planets revolving round it by fluid motion. With this conclusion the motion of our solar system through space is referred to the same cause as the motion of all bodies known to us, namely, fluid motion in an ether composed of two fluids.

But though a general explanation of the motion of our solar system is sufficient for our purpose, and we are not concerned to follow closely the movements of its parts, we are nevertheless closely concerned with the fact that these parts move in some such way as that in which they do: because such movements can be shown to be appropriate to the last stage in a course of building operations, such as that we have now reached in our explanation. We know from our own experience in building operations that much sweeping up has to be done after buildings have been completed.

And in the case of the universe we know that both meteorites and cosmic dust are still free in space; and if these, then of necessity rarefied gases also. Therefore, we see that sweeping-up work still remains to be done in the universe in the same way

as such work remains to be done after our own buildings have been put up.

We can readily see also how a great solar system drifting through space with a host of planets—some large, some small—revolving round a great central sun, in a plane at right angles to the direction in which the whole system is advancing, forms an admirable machinery for sweeping up meteorites and gases, since the planets may be likened to great scoops or fists thrust out to vast distances.

In this connection we may remember that Helmholtz pointed out that the earth and the planets have for millions of years been sweeping together the loose masses in space.¹

We may remember also that Sir William R. Grove pointed out that 20,000,000 of meteorites, visible to the naked eye, fall on an average into our atmosphere in each twenty-four hours.²

There can be no doubt, therefore, as to the efficiency of our solar system as a machine for sweeping up meteorites and cosmic dust. And, in regard to its capabilities in the way of sweeping up rarefied gaseous masses, we have Professor C. V. Boys' photographs of flying rifle bullets, which show that rifle bullets, flying at a velocity of 1300 feet per second and upwards, condense the air in front of them to such an extent that the waves of condensed air thus

¹ "Popular Lectures on Scientific Subjects," second series, translated by Atkinson, p. 170.

² *Nature*, vol. xxxvii. p. 618.

formed are visible in photographs of the flying bullets.¹

We have also the fact pointed out by Sir William R. Grove, that our "earth's motion round the sun carries us through space more than a million and a half of miles a day."² Thus our earth is moving through space at a velocity above seventeen miles per second, or about seventy times as fast as a rifle bullet flying at a speed of 1300 feet per second. We therefore conclude that our earth, with its great body moving through space with this prodigious velocity, forms a great machine for condensing gases by collecting them into its atmosphere.

But if we view our earth in this way, as a machine for sweeping up and collecting rarefied gas into an atmosphere from space, we perceive that it needs to be supplemented by machinery for continuously removing gases from its atmosphere, and packing them up and putting them away, otherwise it will become clogged, since after condensing a sufficient quantity of gas to fill its atmosphere, it will be unable to collect any more for want of room in which to keep it.

Now we have the clearest evidence that gases in vast quantities have been in past ages removed from our earth's atmosphere.

Professor Bunge points out that "oxygen is constantly becoming fixed in the crust of the earth.

¹ *Nature*, vol. xlvii. p. 420.

² *Ibid.*, vol. xxxvii. p. 618.

. . . The constituent of the earth's crust which binds it is the ferrous oxide resulting from the decomposition of certain silicates. This becomes oxidised to ferric oxide, which, as is well known, forms by itself considerable strata, and occurs in still larger quantities mixed with other materials, as clay, loam, sandstone, and shale. One-third of the oxygen in these huge masses of ferric oxide is derived from the atmosphere."¹

Thus we see that the presence of huge masses of ferric oxide in the earth's crust affords clear evidence that one of the gases of the atmosphere, namely, oxygen, has been removed in vast quantities from the atmosphere in the past.

But there is just as clear evidence of the removal from the atmosphere of another of the gases of the atmosphere, namely, carbonic acid or carbon dioxide gas. Only, carbonic acid is removed on a far more gigantic scale than oxygen is removed. For Professor Bunge points out that "half the entire weight of the thick calcareous strata, which compose a very large part of the crust of the earth, consists of carbonic acid, derived from the atmosphere."²

Thus we learn that a large part of the rocks on our earth's surface consists of gases which have been removed from the atmosphere, and packed up, and put away in the solid form in the rocks on the

¹ "Text-book of Physiological and Pathological Chemistry," translated by Wooldridge, p. 18.

² Ibid., p. 18.

earth's surface, while our earth was performing its journey through space with the solar system of which it forms a part.

But Professor Bunge tells us how carbonic acid is taken up by the rocks. He says that "the rocks which form the solid crust consist principally of silicates and carbonates—of compounds of silicic and carbonic acids with lime, magnesium, suboxide of iron, and alkalies." And that carbonic acid is taken up by "the displacement of the silicic acid from the stone of the earth's crust by the carbonic acid of the atmosphere."¹

But then he also points out that the displacement of silicic acid by carbonic acid only occurs at the surface of the earth, "in the cold and in the presence of water," where "the carbonic is the more powerful acid."

For "the struggle," adds Professor Bunge, "between the two acids wears another aspect in the interior of the earth. At the higher temperature which prevails there, the silicic acid is the more powerful. In the depths of the earth it attacks the carbonates, and the carbonic acid which is driven off escapes into the atmosphere. This carbonic acid is continually issuing from all active volcanoes, and also from other cracks and fissures in various parts of the earth."²

It is manifest that the chalk hills and limestone

¹ "Text-book of Physiological and Pathological Chemistry," translated by Wooldridge, p. 17.

² Ibid., p. 18.

mountains in which carbonic acid is stored up did not form part of the original structure of the earth, because, as Professor Bunge points out, carbonic acid is taken up by the rocks "in the cold and in the presence of water." And, in fact, we know from our experience in lime-burning, that limestone and chalk part with all their carbonic acid, and are reduced to lime or calcium oxide, as the chemist calls it, at a temperature of about 600° .

The limestone mountains and chalk hills must, therefore, have been formed after the body of the earth had cooled down sufficiently for water vapour to condense upon it. The correctness of our conclusions in this respect is shown by the fact that masses of limestone and chalk usually contain the fossil remains of animal forms, and are even in some cases built up entirely of such fossil remains; and therefore must necessarily have been built up after life had made its appearance, and therefore after the surface of the earth had quite cooled down.

The great limestone mountains and chalk hills, since "half the entire weight" of them consists, as we have seen at page 186, of carbonic acid removed from the atmosphere, tell us plainly of great activity in past ages in the way of removing carbonic acid gas from the atmosphere, and packing it up and putting it away in a solid form in the earth's crust.

But the coal beds tell the same fact also, since "coal," says Professor Bunge, "is, as we well know,

"the residue of plants, and plants derive their carbon from the carbonic acid of the atmosphere."¹

And we learn from Chemistry that "fossil coal contains 90 per cent. and brown coal 70 per cent. of carbon," and that "the fossil coal richest in carbon . . . is *anthracite*," which "contains 96 to 98 per cent. of carbon."²

Hence the great coal beds, formed as they are mainly of carbon derived by plants "from the carbonic acid of the atmosphere," tell of great activity in past ages on the part of plants in removing carbonic acid from the atmosphere.

But plants, as Professor Bunge tells us, take up carbonic acid and water, and, by the aid of sunlight, "split off from these combinations a part of the oxygen, and form compounds richer in carbon and hydrogen,"³ and, therefore, pack up and put away a part only of the atoms of matter contained in carbonic acid gas.

Now we know from chemistry that the carbonic acid molecule consists of one atom of carbon united to two atoms of oxygen.

Thus we see that plants take up all the carbon, but a part only of the oxygen atoms from the molecules of carbonic acid gas, and leave a part of

¹ "Text-book of Physiological and Pathological Chemistry," translated by Wooldridge, p. 15.

² "Inorganic Chemistry," by Professor Victor von Richter, translated by E. F. Smith, p. 152.

³ "Physiological and Pathological Chemistry," translated by Wooldridge, p. 16.

the oxygen atoms unused. And we have seen above, at page 185, that the rocks take up oxygen atoms.

Hence we conclude that carbonic acid is removed from the atmosphere of our earth by plants and rocks together, the plants removing the carbon atoms and part of the oxygen atoms in the carbonic acid molecules, and the rocks removing the oxygen atoms which are left: and that the great coal beds, representing as they do vast stores of carbon, removed in that way by plants from the atmosphere, and packed up and put away in the solid form in the earth, give us some idea of what plant life is able to do.

Hence we conclude that the great coal beds, formed of carbon taken out of the carbonic acid gas of the atmosphere by plants, show us, together with "huge masses of ferric oxide," formed by the oxidation of ferrous oxide by oxygen taken out from the atmosphere, and along with the great limestone mountains and chalk hills representing vast masses of lime which have taken up carbonic acid gas from the atmosphere, and been thereby converted into carbonate of lime, that there has been in past ages great activity on our earth's surface in removing carbonic acid gas from the atmosphere, and packing it up, and putting it away in the solid form in the earth's crust; and that carbonic acid gas in vast quantities has been packed up and put away as the result of this activity.

Now the weight of our earth's atmosphere is, as we learn from Principal Oliver Lodge, about 14.6 lbs. per square inch.¹ And we learn from Professor Victor von Richter that the gas density of carbonic acid or carbon dioxide equals 1.527 (air = 1),² and, therefore, that carbonic acid is about one and a half times as heavy as air.

Hence we see that if our earth's atmosphere consisted entirely of carbonic acid, it would weigh about 22 lbs. per square inch instead of 14.6 lbs. as at present.

Now limestone weighs, as we learn from Professor Rankine, about 156 lbs. to the cubic foot, or say $\frac{1}{11}$ of a lb. per cubic inch.

And since, as Professor Bunge points out in the quotation on page 186, half the entire weight of the thick calcareous strata, which compose a very large part of the earth's crust, consists of carbonic acid derived from the atmosphere; it follows that if our earth's atmosphere consisted entirely of carbonic acid, there would be enough carbonic acid in it to form a calcareous stratum about $22 \times 11 \times 2 = 484$ inches, or $40\frac{1}{2}$ feet in thickness over the surface of our earth.

But our earth's crust is many thousands of feet in thickness. "In South Wales, for example," says Sir Charles Lyell, "the thickness of the coal-bearing

¹ "Elementary Mechanics," revised edition, p. 178.

² "Inorganic Chemistry," translated by E. F. Smith, p. 231.

strata has been estimated at between 11,000 and 12,000 feet.”¹ And again, the same authority tells us, “that in the central and northern coalfields of England . . . the productive coal measures . . . are nearly 10,000 feet thick.”² And since, as we have seen, a whole atmosphere of carbonic acid would only yield enough carbonic acid for a calcareous stratum 40 feet in thickness, we perceive that many atmospheres of carbonic acid would be required for the formation of calcareous strata thick enough to form a very large part of the earth’s crust.

And we conclude that the existence of such strata on the earth’s surface, with “half the entire weight of them consisting of carbonic acid derived from the atmosphere,” is proof positive that our earth has picked up vast quantities of carbonic acid gas since it was first formed.

And we also conclude that the vast quantity of carbonic acid which is represented by the vast amount taken up in forming calcareous strata, and used up in forming the coal beds, and in forming the plants and trees now existing on the earth, could not have been retained unless plants and rocks had been continuously at work in packing it up and putting it away in the solid form.

Having reached this conclusion, the point to

¹ “Student’s Elements of Geology,” p. 375.

² *Ibid.*, p. 376.

notice next is that the rocks, as pointed out by Professor Bunge, only take up carbonic acid "in the cold and in the presence of water." "Every wave," says Professor Bunge, "breaking against the cliffs, every ripple which washes the flinty bed of the river, every drop of rain which falls to the ground, contains carbonic acid in solution, and slowly but surely destroys the hardest rock; the carbonic acid unites with the basic constituents, and the displaced silicic acid combined with the residue of the bases sinks to the bottom of the water, where, as clay or sandstone, it gradually forms massive strata of the earth's surface."¹ But while the rocks only take up carbonic acid in the presence of water, plants, on the other hand, as we find, take up carbonic acid gas from the atmosphere in the presence of sunlight. ". . . The plant," says Professor Bunge, "is always taking up carbonic acid."² And again, "Plants derive their carbon from the carbonic acid of the atmosphere."³

Thus we see that the rocks take up carbonic acid mainly from the water, and plants take it up mainly from the atmosphere; though some carbonic acid is taken up by the rocks from the atmosphere and by plants from water. Hence we see that rocks and plants work side by side in taking up

¹ "Physiological and Pathological Chemistry," translated by L. C. Wooldridge, p. 17.

² Ibid., p. 33.

³ Ibid., p. 15.

carbonic acid, rocks taking it up from the water, and plants taking it up from the atmosphere.

But there is another and still more important point to notice, and that is the fact that plants under favourable conditions spring up with prodigious rapidity, and therefore supply a machinery for dealing with sudden intakes of carbonic acid gas. The rocks, on the other hand, supply a machinery which works slowly though continuously, and thus machinery not in any way suited for dealing with violent fluctuations. With the condensing machinery supplied by the rocks the carbonic acid gas must first be taken up by water, and not till then does it begin to combine slowly with the basic constituents of the rocks, displacing silicic acid from their constituents. The process is, in fact, one which works "slowly but surely," as Professor Bunge, as we have seen, points out.

But our earth in its journey through space may conceivably at one time be passing through tracts of space comparatively rich in carbonic acid, and at another time through tracts very poor in carbonic acid, and thus may at times be able to take up vast quantities of carbonic acid and at other times very little.

And, indeed, we have, in the fact that coal occurs in seams which are sometimes separated by thick layers of sandstone or other forms of rock, indications that fluctuating amounts of

carbonic acid have actually had to be dealt with if we remember that coal consists of the remains of plants, and that plants are built up mainly of carbonic acid removed from the atmosphere.

In this connection we may notice a remark of Sir Charles Lyell's in regard to the Yoredale series, which "attain a thickness of from 800 to 1000 feet." "Thin seams of coal," says Sir Charles Lyell, "also occur in these lower Yoredale beds in Yorkshire, showing that in the same region there were great alternations in the state of the surface. For at successive periods in the same area there prevailed, first terrestrial conditions favourable to the growth of pure coal, secondly, a sea of some depth suited to the formation of carboniferous limestone, and, thirdly, a supply of muddy sediment and sand, furnishing the materials for sandstone and shale."¹

We learn, also, from the same authority, that in South Wales "the thickness of the coal-bearing strata has been estimated at between 11,000 and 12,000 feet, while the various coal seams, about eighty in number, do not, according to Professor Phillips, exceed in the aggregate 120 feet."²

Professor Bunge also expressly points out that: "As regards carbonic acid, the geologists are of

¹ "Student's Elements of Geology," p. 376.

² Ibid., p. 375.

opinion that there was formerly a larger amount in the atmosphere."¹

Hence we conclude that there was need of machinery for dealing with sudden intakes of carbonic acid, as well as a need of machinery for dealing with a continuous intake: and while we find, accordingly, that the rocks supply a continuously but slowly working machinery of enormous power for storing a constant intake of carbonic acid, we find, at the same time, that the plants, and especially the great forest trees, taking up as they do directly and at once carbonic acid from the atmosphere, and rearing as they do, from the vantage points which mountain ranges offer, their heads high into the atmosphere, offer machinery of immense power for dealing with any sudden intakes of carbonic acid. Thus we find that rocks and plants together supply a machinery nicely adjusted to suit the varying conditions which have to be faced in connection with the collection and storage of gases.

We have found that our earth, in its rapid flight through space, is as a portion of our solar system a machine for condensing rarefied gases and gathering them into its atmosphere, and thus is a machine for sweeping up gases which are loose in space, and a machine of immense power.

¹ "Physiological and Pathological Chemistry," translated by Wooldridge, p. 16.

And now we find in the rocks and plants a machinery for packing up the gases which the earth sweeps up and putting them away in the solid form so that room may always be available in the earth's atmosphere for taking in gases, and thus no clogging of the sweeping machinery may take place; and also find in them a machinery of immense power.

Hence we see that plant life comes in to supply a need, and is a process of collecting atoms of matter and packing them up in the same way as chemical affinity and cohesion are processes of collecting atoms.

We are engaged here in dealing with broad facts, and therefore do not propose to make any attempt to go into the details of the process by which life collects atoms of matter from the atmosphere and packs them up and puts them away in the solid form in the crust of the earth. The details, so far as they are known, are duly set forth in the various text-books of science, and can therefore be studied by any one who wishes to look into them.

We must notice, however, the broad fact that all forms of life, whether they are of the plant form or the animal form, either consist of single cells or of colonies of cells, and thus that all are cellular in structure.

Professor Sir William Turner, in the Presidential Address to the British Association at the Bradford

meeting on the 6th September 1900, remarked that "in 1839 Theodore Schwann announced the important generalisation that there is one universal principle of development for the elementary part of organisms, however different they may be in appearance, and that this principle is the formation of cells. The enunciation of the fundamental principle that the elementary tissues consisted of cells . . . provided biologists with the visible anatomical units through which the external forces operating on, and the energy generated in, living matter come into play. . . . A cell is a living particle so minute that it needs a microscope for its examination; it grows in size, maintains itself in a state of activity, responds to the action of stimuli, reproduces its kind, and in the course of time it degenerates and dies."¹

"That plants consist of cells," says Professor Julius von Sachs, "is now known to every well-informed man."²

Thus we see that plant life, like all other forms of life, works by building up cells out of organic molecules, and thus works much in the same way as cohesion works when it builds up crystals out of inorganic molecules. Plant life, also, in many cases proceeds further to build up masses

¹ *Nature*, vol. lxii. p. 442.

² "On the Physiology of Plants," translated by H. Marshall Ward, p. 73.

of cells in the shape of plants and trees much after the same way as cohesion builds up masses of crystals. There is, however, a fundamental difference between the cell and the crystal, inasmuch as the cell grows by additions from the inside, while the crystal grows by additions on the outside.

The fundamental difference between the procedure adopted by life in putting up its buildings in the shape of plants, and that adopted by cohesion in putting up its buildings in the shape of crystals, points manifestly to a vast difference in the conditions which have to be encountered. Cohesion builds with molecules which are easily laid hold of and put into position. Life builds with molecules formed out of molecules of carbonic acid gas, which, being a permanent gas, eludes all the operations of cohesion. Carbonic acid is, as we learn, "inhaled by the plants."¹ And starch, from which albuminous compounds are prepared, is prepared from molecules of carbonic acid, and molecules of water, by chlorophyll grains which are embedded in the protoplasm of the cell. Hence carbonic acid is dealt with in confinement in the cell. And we may note that the chemist finds it necessary to confine carbonic acid as well as other gases in tubes or otherwise when he dissociates or condenses them.

¹ Professor Victor v. Richter, "Inorganic Chemistry," translated by E. F. Smith, p. 234.

Plant life has not only to build, but it has also to prepare its own building materials, mainly from carbonic acid, by partially breaking up its molecules, which, as we learn from chemistry, are very stable and very difficult to break up.

Plant life, therefore, builds under very different conditions from those which obtain in the building of the crystal by cohesion out of inorganic molecules. Plant life builds, in fact, with a volatile substance which has eluded to a great extent the other building processes, and therefore requires special activities and special appliances.

The appliances of plant life are cells, each of which has a cell-wall, or cell-membrane, enclosing it. Thus carbonic acid gas and other substances, when they are taken into a cell, are walled in and dealt with in confinement in the same way as they are walled in and dealt with in confinement when they are put into tubes in a chemist's laboratory.

The special activities which plant life requires are provided for by masses of contractile protoplasm which line the walls of every living cell, and are in a continual state of movement. "Within," says Professor Bunge, "the rigid cellulose-wall of every vegetable cell is a contractile protoplasmic body which breathes and performs 'active' movements like every animal."¹

¹ "Physiological and Pathological Chemistry," translated by Wooldridge, p. 44.

Again, Professor Sydney H. Vines remarks that, "in a fully developed living cell the following three principal constituents may be distinguished . . . :—

"(i.) A closed membrane, the *cell-wall* consisting generally of a substance termed *cellulose*.

"(ii.) A layer of semi-fluid substance, the *protoplasm* lying in close contact at all points with the internal surface of the cell-wall; the protoplasm gives the chemical reactions of proteid. . . .

"(iii.) Cavities, one or more in the protoplasm, termed *vacuoles*, which are filled with a watery liquid, the *cell-sap*." ¹

And Professor Sachs tells us that "the protoplasm, with its nucleus, and the cell-membrane or cell-wall, appear as the essentials of every vegetable cell;" ² and shows that the chlorophyll bodies by which plant cells prepare starch out of carbonic acid gas, taken in from the atmosphere, and water, "always lie embedded in the substance of the protoplasm;" and that each of these chlorophyll bodies may be looked upon as "a portion of the protoplasm tinged with chlorophyll colouring-matter." ³

Professor von Sachs further points out that the starch thus prepared "provides the material for

¹ "Elementary Text-Book of Botany," p. 66.

² "On the Physiology of Plants," translated by H. Marshall Ward, p. 78.

³ *Ibid.*, p. 85.

. . . the synthesis of the proteid substances,"¹ or albuminous substances, of which protoplasm consists.²

At the same time he points out that "the statement that protoplasm consists of albuminous substances is, however, not to be understood to mean that proteid and protoplasm are identical. . . . Living protoplasm always contains a larger or smaller quantity of water, and if this is withdrawn up to a certain minimum, it loses its vital activity, and, on the withdrawal of more water, even its ability to live. The water belongs to the molecular structure of the living protoplasm in the same sense as the water of crystallisation is necessary to the structure of very many crystals, which lose their crystalline form on the withdrawal of the water of crystallisation."³

He also points out that albuminous substances are "the most complex of all organic chemical combinations."⁴

The active contractile protoplasm lining the cell-wall deals thus with carbonic acid gas in confinement within the cell-walls, and is thus able, by its contraction, to condense the carbonic acid gas, or deal with it by other movements. In fact it selects from the carbonic acid molecules the portion it requires, namely, the carbon atoms and part of the oxygen atoms, and rejects the remainder, namely,

¹ "On the Physiology of Plants," translated by H. Marshall Ward, p. 312.

² Ibid., p. 79.

³ Ibid., p. 79.

⁴ Ibid., p. 79.

the remaining oxygen atoms; it also selects from molecules of water the portion it requires, namely, the hydrogen atoms and part of the oxygen atoms, and rejects the remainder, namely, the remaining oxygen atoms. In this the plant cell behaves as all other living cells behave.

"But this enigma confronts us everywhere," says Professor Bunge, "in living tissue. Each cell has the power of attracting or rejecting different materials, according to the object they are destined to fulfil, and of forwarding them in different directions."¹ And again he says, "Every cell acquires the faculty of rejecting some substances, of attracting others and storing them up, thereby attaining the composition necessary for the due fulfilment of the functions it has to perform."²

Professor Bunge also remarks that the "chief bulk of the oxygen enters the organisation of plants as water and as carbonic acid. By the aid of sunlight the plants split off from these combinations a part of the oxygen, and form compounds richer in carbon and hydrogen."³

And Professor Victor v. Richter tells us that carbonic acid, or carbon dioxide, as it is called by chemists, "is present in the atmosphere, and

¹ "Physiological and Pathological Chemistry," translated by Wooldridge, p. 164.

² *Ibid.*, p. 6.

³ *Ibid.*, p. 16.

is inhaled by the plants. The chlorophyll grains in the green parts of the plant decompose carbon dioxide in sunlight, with a partial separation of oxygen; by the mutual action of water and ammonia, the innumerable carbon compounds peculiar to plants are formed from the residue." ¹

Hence we see that living plant cells in the green parts of plants behave as do all other living cells, in that they attract and store up certain materials and reject others; and we find that the materials so selected and stored up, are, in the case of plant cells, principally carbon and hydrogen atoms, and the materials rejected are principally oxygen atoms.

But the next point to notice is, that all the cells in plants are not necessarily living cells. We learn that, "With increasing age, and according to the physiological work which the cells . . . have to fulfil in the life of the plant, both the chemical and the physical properties of the cell wall become changed. . . . Three chief cases of metamorphoses of the substance of the cell-wall" are of "especially frequent occurrence; these are, lignification, suberisation, and the conversion into mucilage. Lignification, which we find in the typical form in the empty cells of ordinary wood, . . . is usually associated with a considerable thickening of the otherwise very thin cell-walls. It is due to the formation of a peculiar

¹ "Inorganic Chemistry," translated by E. F. Smith, p. 234.

chemical compound. . . . In a certain sense, the suberisation of the cell-wall forms the contrast to its lignification; it consists in that in the basis of cellulose another substance, *suberin* or cork substance, is deposited."¹

Hence we see that in the course of time a change comes over the plant cell, and in the case of trees the solid cell-walls of many of the cells become gradually thickened by woody matter or lignin, or by cork substance or suberin being stored up within them, while, at the same time, the lining of active fluid protoplasm becomes thinner, and at last disappears, and all activity in the cell is at an end. The cell then represents a wall built up of solid matter, taken out mainly from the atmosphere. It affords, indeed, a stable foundation from which living cells may operate, and a channel through which fluid sap may circulate, but is itself absolutely inert.

With increasing age the tree builds up more and more of these hard woody cells, until at length it becomes so lofty, and its cells form such a dense mass, that the sap which conveys water and salts from the roots to the leaves, and starch and albuminous substances from the leaves to the branches and roots, can no longer circulate freely. The tree then to a great extent loses its power of taking up

¹ Professor Julius v. Sachs, "On the Physiology of Plants," translated by H. Marshall Ward, p. 87.

carbonic acid from the atmosphere, and represents a mass of matter removed from the atmosphere and packed up in the solid form by a machine which has stopped working or nearly stopped. Thus it is clear that a great forest tree lifting its head high up into the atmosphere represents a great machine for collecting carbon from the carbonic acid or, as it is now called, carbon dioxide gas in the atmosphere, and hydrogen from the water, and packing up and putting away the carbon and hydrogen so collected, in the form of starch, cellulose, albumen, &c., permanently in its great trunk and limbs or temporarily in leaves and flowers periodically shed. But at the same time the great forest tree, mighty as it is as a machine for collecting gases when in working order, most plainly represents also a machine which if left to itself will get clogged in course of time. It will, in fact, become dense with age and quite full of solid matter, and will then cease to collect vigorously. The result, if no machinery for clearing away dead and dying trees were available, would be that the surface of the earth would, in the course of a few centuries, be covered with a tangled mass of dead and dying trees, defying with interlocked branches the action of wind and weather and leaving no room for young trees.

Hence we see that the forest tree viewed as a machine needs supplementary machinery to gather in what it collects.

We have seen that our earth, viewed as a machine for collecting gases from space, is a machine which will get clogged if left to itself, inasmuch as if left to itself it will condense enough gases to fill up its atmosphere and will then cease to collect any more. We have seen that the earth as a machine for condensing gases needs for continuous working to be supplemented by machinery for removing gases from its atmosphere and packing them up and stowing them away; and we have seen that the forest tree, with the assistance of shrubs and herbs, supplies the needful machinery for removing gases from the atmosphere along with the rocks. But now we see that the forest tree, if left to itself, will in its turn get clogged also, and needs therefore to be supplemented by other machinery for removing, and putting away the masses it collects, just as the earth needs to be supplemented by machinery for removing, packing up, and putting away what it collects.

And then we perceive that the necessary machinery for supplementing the operations of the forest tree has been provided in the shape of animal life which in all its forms is built, as we have seen at p. 197, of cells consisting largely of protoplasm during the growing stages, and thus in this respect resembles plant life. At the same time we find that animal life is unable to elaborate for itself albumen required for the formation of the

protoplasm, &c., of which cells are built up, or starch; but is compelled to obtain supplies of these vital necessities from plant life, and is thus compelled by its necessities to prey upon plant life.

From Professor Ernst Haeckel we learn that "Albert Kölliker and Rudolph Virchow took up the cellular theory, and the theory of tissues which is founded on it, in the sixties, and . . . proved that, in man and all other animals, every tissue is made up of the same microscopic particles, the *cells*, and these 'elementary organisms' are the real, self-active citizens which, in combinations of millions, constitute the 'cellular state,' our body. All these cells spring from one simple cell, the *cytula*, or impregnated ovum, by continuous sub-division."¹

We find that animal cells resemble plant cells in that they consist when living each essentially of a mass of protoplasm, but differ from plant cells, in that, like the cells of fungi, they have no chlorophyll bodies, and are thus unable to prepare starch molecules from the carbonic acid gas in the atmosphere or albumen molecules from starch.

Professor Bunge tells us that "there are unicellular beings, without chlorophyll, such as fungi and bacteria, which are incapable of assimilating the carbon of carbonic acid. . . . Here they resemble animals."²

¹ "The Riddle of the Universe," translated by J. McCabe, p. 26.

² "Physiological and Pathological Chemistry," translated by Wooldridge, p. 44.

And Professor Sachs tells us that "the fungi are not able to decompose carbon dioxide, and thus to produce carbonaceous organic substance, because they lack chlorophyll."¹

Since each living cell consists essentially, as we have seen, of protoplasm, and protoplasm is built up, as we have seen, by water molecules out of molecules of albumen, the animal cell manifestly requires a supply of albumen-molecules to enable it to grow; but the animal cell is unable to prepare for itself the starch molecules out of which molecules of albumen are formed, and is, therefore, obliged to obtain its supplies of starch and supplies of albuminous substances from plants.

"The plant," says Professor Bunge, "forms organic substances; the animal destroys organic substances. The vital process in the plant is synthetic, in the animal analytic."²

Hence, at first sight it appears that we have in life a cycle, since the animal undoes the work of removing carbon, hydrogen, and oxygen from the atmosphere which the plant does.

But, if we look closer, we shall perceive that the animal undoes only a part of the work which the plant does. For the plant cell consists, as we have seen at p. 201, not only of a mass of protoplasm, and thus of albuminous substances, but also of a cell

¹ "Physiology of Plants," translated by H. Marshall Ward, p. 383.

² "Physiological and Pathological Chemistry," translated by Wooldridge, p. 43.

membrane or cell wall. And in regard to the cell wall, Professor Sachs tells us that "the cell-membrane or cell-wall forms . . . the external solid boundary of the cell. In its primitive state it consists of a peculiar chemical compound cellulose, which is composed of carbon, hydrogen, and oxygen," and is "remarkable for its great resistance to the most various chemical solvent reagents. . . . With increasing age . . . the chemical and the physical properties of the cell-wall become changed," amongst other ways by "lignification, which we find in the typical form in the empty cells of ordinary wood."¹

Hence we see that plants contain not only soft watery protoplasm, with chlorophyll and starch grains contained in the protoplasm, but also solid cellulose and woody fibre.

And animals require, as we have seen, supplies of albuminous substances, and thus the whole of the protoplasm, which consists, as shown above, of albuminous substances, but do not require the cellulose or woody fibre which plants also, as we have seen, contain, or at all events in no case require the whole of the cellulose and woody fibre.

Professor Bunge states that "it was proved by experiments on ruminants, at the farm-stations kept for investigations, that from 60 to 70 per cent. of the woody fibres disappear from the digestive canal. . . .

¹ "Physiology of Plants," translated by H. Marshall Ward, p. 87.

"Later on, Knieriem made experiments on himself, and found that he digested 25.3 per cent. of the tender woody fibres of lettuce, while only 4.4 per cent. of the tougher fibres of the scorzonera."¹

But the animal usually, as we all know, eats only the softer parts of plants, and leaves the harder parts, the tough, hard wood, alone.

Hence we see that when plants are eaten by animals as food a small proportion of the soft parts of the plants, and a large part of the hard parts, pass out undigested from the animal body. Thus we see that the animal destroys only a portion of the organic substances which the plant builds up, even when plants are eaten by it. At the same time, we know that plants usually are not eaten up, but have merely the most succulent parts removed from them. The animal selects the portions it requires.

Professor Bunge tells us that "at the present time we know that all unicellular organisms possess the power of selecting their food, of taking up the useful and rejecting the useless substances. In this connection I may relate," he says, "an interesting observation made by Cienkowski on an amœba called the *Vampyrella*. The *Vampyrella Spirogyræ* is a minute red-tinged cell, devoid of any special limiting membrane, and apparently quite structureless. . . .

¹ "Physiological and Pathological Chemistry," translated by Wooldridge, p. 81.

This minute mass of protoplasm will take but one form of food, a particular variety of algæ—the *Spirogyra*. It can be observed to send out pseudopodia and to creep along the *confervæ* until it meets with a *Spirogyra*; then it affixes itself to the cellulose coat enclosing one of the cells of the latter, dissolves the coat at the point of contact, sucks in the contents of the cell, and travels to the next to repeat the proceeding. Cienkowski never saw the *Vampyrella* attack any other class of algæ, or even take up any other substance; *vaucheriæ*, *œdogniæ*, purposely placed before it, were always rejected.”¹

Thus we see at the very foundation of animal life a selective action at work. We see an *amœba* selecting not only the particular kind of plant, but also the particular part of a plant which it requires for its use, and therefore for destruction, and leaving the remainder, the hard part. We see it selecting what is to be destroyed and leaving the remainder.

But Professor Bunge shows that not only do “all unicellular organisms possess the power of selecting their food, of taking up the useful and rejecting the useless,” but all the cells of all the tissues of all animal forms have the same power.

“We know,” he says, “that the intestinal wall is covered with epithelium, and that every epithelial cell is in itself an organism, a living being with the

¹ “Physiological and Pathological Chemistry,” translated by Wooldridge, p. 4.

most complex functions; we know that it takes up food by the active contraction of its protoplasm in the same way as observed in independent naked animal cells, such as amœbæ and rhizopods. Observations on the intestinal epithelium of cold-blooded animals have made it obvious that the cells grasp the particles of fat contained in the food by means of protoplasmic processes which they send out; that they incorporate the fat globules with the protoplasm of the cell, which finally passes them on to the commencement of the chyle vessels. As long as this active intervention of cells was unknown, it was impossible to understand the remarkable fact that, although the minute drops of fat were able to pass through the intestinal wall, yet finely-divided pigments, intentionally introduced into the intestine, remained quite unabsorbed.”¹

“Just as the *Vampyrella* picks out the *Spirogyra* from amongst all other algæ, so do the epithelial cells of our intestine select the fat drops and reject the pigment granules.”²

Professor Bunge goes on to say that “it was . . . once thought that the activity of glands and the processes of secretion were in the main explicable by osmosis. But we now know that here, too, the epithelial cells play an active part. Here again we find the same mysterious power of selection,

¹ “Physiological and Pathological Chemistry,” translated by Wooldridge, p. 3.

² *Ibid.*, p. 5.

of picking out certain constituents of the blood, of altering them by processes of synthesis and decomposition, of sending some into the ducts of the glands and others back into the lymph and blood. The epithelial cells of the lacteal gland collect all the inorganic salts from the blood—which has a totally different constitution—in the exact proportion required by the infant, that its growth and development may assimilate it to its parents. These phenomena cannot at present be explained by the laws of diffusion and osmosis.

“All the cells of our tissues possess the same wonderful powers as the leucocytes and epithelial cells of the alimentary canal, and of glands. Consider the mode of development of our organism: all tissue elements are produced from a single ovum, and in proportion as the cells increase by segmentation they become differentiated on the principle of the division of labour; every cell acquires the faculty of rejecting some substances, of attracting others, and storing them up, thereby attaining the composition necessary for the due fulfilment of the functions it has to perform.”¹

Professor Bunge tells us also “that the blood brings to the glandular cells everything which is necessary to fulfil their functions.”²

Thus we see that animal life selects certain parts

¹ “Physiological and Pathological Chemistry,” translated by Wooldridge, p. 5.

² *Ibid.*, p. 174.

of plants, namely, the soft parts, for its own use, and therefore for destruction; and it rejects other parts, namely, the hard parts.

But there is another point; for we find that animals which deal directly with plants, namely, herbivorous animals, although they require the soft parts only of plants, are yet obliged to take into their bodies a certain proportion of the hard parts along with the soft parts.

We have seen that animal cells, being unable to prepare starch and albuminous substances for themselves from carbonic acid gas and water, are obliged to obtain these materials from the soft parts of plant cells which contain these materials, and thus use the soft parts of plant cells, but reject, to a great extent, the hard cell walls which consist of cellulose and other solids. And yet we learn that herbivorous animals are obliged to take in cellulose, even though they do not digest it. Cellulose has, in fact, to be taken in order to cause sufficient irritation to induce in the intestine the peristaltic action by which the contents of the intestine are moved forwards along the intestine.

"Cellulose," says Professor Bunge, "can scarcely be classed among the food substances of human beings. On the other hand, it is of great importance in acting as a mechanical stimulus to promote the peristalsis of the intestine. For this reason cellulose is absolutely essential to animals with a long

intestinal tract. If rabbits are fed on a diet containing no cellulose, the onward movement of the intestinal contents ceases, inflammation in the intestines ensues, and the animals rapidly die. But if horn parings be added to the same food, nutrition is normal. These horn parings are, as Knieriem proved by experiments devoted to that purpose, absolutely undigested, and can, therefore, only have taken the place of woody fibre in so far as its mechanical properties were concerned.”¹

Professor Bunge adds that, “The short intestine of carnivora does not require a mechanical stimulus to produce peristaltic action.”²

Hence we see that herbivorous animal life is so constituted as to be obliged to take into its body a certain proportion of the hard parts of plants—of the woody fibre—which it does not digest, in addition to the soft parts, which it does digest. And in order that the hard parts so taken in may move freely through the stomach, and in order that the soft parts inside these hard parts may be freely exposed to the digestive juices, these hard parts have to be broken up and finely macerated by the jaws.

The hard parts so broken up pass out from the stomach in a form in which they can readily mix with the soil of the earth.

A portion of the hard parts of plants are dealt

¹ “Physiological and Pathological Chemistry,” translated by Wooldridge, p. 82.

² *Ibid.*, p. 83.

with in this way, the remainder are dealt with by boring insects, which bore into the densest trees to get at the sugar and other soft parts in the cells inside. The holes made by boring insects give entrance to the spores of fungi, which are, as we have seen at page 208, unable to prepare starch or sugar for themselves from the carbonic acid gas of the atmosphere, and are obliged to obtain their supplies from plants. In obtaining their supplies they carry on and complete the work of the boring insects, and reduce the great tree trunks to masses more finely divided up even than are the hard parts which pass through the bodies of herbivorous animals.

We have just seen that herbivorous animals are so constituted that they are compelled to take into the stomach a certain amount of indigestible food in the shape of the woody fibres or hard parts of plants, which cannot be destroyed in the body, in addition to the soft parts which they are able to digest and assimilate. On this basis only can they remain in health and activity.

In fact, we all know that herbivorous animal life destroys only a portion of the organic substances which it takes into its stomach. The remainder, namely, the hard woody fibres which it is unable to digest, are cut and ground up by the teeth, and then pass out from its stomach in a finely divided form, in which they are able readily to mix with the soil of the earth.

Hence we see that herbivorous animal life is a destroying agency in respect of the soft parts of plant life, which it digests, and a collecting or harvesting agency in respect of the hard parts, which it cuts down and breaks up with its jaws and takes into its stomach, but is unable to digest.

We find that herbivorous animal life keeps plant life in working order by cutting away weak and sickly and redundant forms, and pruning luxuriant growth for the sake of the soft parts which these furnish abundantly.

But in addition to the thinning and pruning work thus done upon living forms of plant life, herbivorous animal life, in some of its insect forms, does much work in the way of clearing off dead forms of plant life.

The dead forms which, if left alone, would cumber the ground to such an extent as, in course of time, to leave no adequate room for living forms, are cut into, as we have seen at page 217, by boring insects, in order to get at the stores of sugar and other food substances contained in their cells, and thus ways are opened for the entrance of bacteria and fungi which complete the work of destruction.

In this way all dead forms are cut down in course of time, and either broken up into a mouldering mass, which readily mingles with the soil, or are swept away by floods, and buried under strata of mud or sand.

Hence we see that herbivorous animal life, in its various forms, from minute bacteria up to the mighty elephant, is a machinery for supplementing the work of plant life; inasmuch as it cuts down, cuts up, and helps to put away in the strata of the earth the stores of matter which plant life collects from the atmosphere. It further keeps the machinery of plant life in working order by clearing away, not only the dead forms which would clog the machinery, but also the weak and sickly and redundant forms which would retard it. Thus we see that herbivorous animal life meets a need just as plant life meets a need.

But before passing on, it is necessary to notice one point of great importance in connection with the operations of herbivorous animal life. This is the fact that the usefulness of herbivorous animal life as a machinery for supplementing the operations of plant life is vastly enhanced by the principle of *division of labour* which prevails throughout the animal world, owing to the restrictions put upon each kind of animal in regard to the range of its diet and the range of its habitation.

The restriction in the range of diet is imposed in the shape of likes and dislikes, which impel the animal to eat certain kinds of plants, and compel it to leave other kinds of plants alone.

The restriction on the range of habitation of an animal is imposed, sometimes in the form of a thick

coat, sometimes in the form of a thin coat, and sometimes in the form of a coat of some particular colour, and sometimes in the shape of limbs of a peculiar form, or of a constitution of a particular kind, and sometimes also in other ways. These peculiarities adapt it for living in certain tracts, and in these only, and thus restrict it.

The effect of these restrictions is to bring about a division of labour in the herbivorous animal world in which the various kinds of herbivorous animals are told off, and restricted each to certain kinds of plants.

The effect of this division of labour is to give plants of all kinds each its own staff of attendants, and thereby ensure each kind's getting a proper share of attention, and at the same time save it from getting too much.

The stern modes, by which the maintenance of this division of labour is enforced, show how fully the necessity of maintaining it is recognised in nature.

We find that the necessity of attending to their likes and dislikes is impressed upon animals by a dire array of poisons which deal pain or sickness or death to those which eat plants of the wrong kinds.

We find also that the necessity of keeping to the tract of country for which it is fitted by the nature of its coat, or the character of its constitution, is

impressed upon an animal by a list of dreadful diseases which deal pain and sickness and death to transgressors.

And then, lest poison and disease should fail to restrain the herbivorous animal from transgressing, there is superadded a host of carnivorous animal foes, ever ready to pull it down if it weakens itself in any way by taking improper food, or by straying into regions unsuited to its health or to its limbs. Thus the herbivorous animal in a state of nature is effectually prevented from transgressing even a little.

We are thus brought naturally to a consideration of the operations of carnivorous animal life, which has many forms, ranging from the minute pathogenic bacillus to the lordly lion.

Carnivorous animal life, like herbivorous animal life, is built up of cells consisting largely of protoplasm, but is unable to utilise the stores of albumen plant life contains for the elaboration of protoplasm, and is compelled to obtain from herbivorous animal life the stores of albuminous matter it requires.

We have seen that herbivorous animal life is unable to elaborate albuminous substances from the gases in the atmosphere in the same way as plant life does, and is consequently forced by its wants to prey upon plant life.

And now we see that carnivorous animal life is

unable to assimilate the albuminous substances elaborated by plant life, but, at the same time, has the same need of stores of albumen that herbivorous animal life has. Hence carnivorous animal life is forced in its turn to prey upon herbivorous animal life in order to obtain the necessary supply of albuminous substances.

Herbivorous animal life keeps, as we have seen, the machinery of plant life in working order by destroying weak, sickly, and redundant forms, and clearing away aged and dead forms.

We have now to notice that carnivorous animal life plays towards herbivorous animal life the same part as herbivorous animal life plays towards plant life, inasmuch as it destroys the weak and sickly and redundant forms, and also clears away the aged and the dead. But carnivorous animal life does even more than this for herbivorous animal life, since it exercises over herbivorous animal life a distinct control which is most distinctly necessary. For herbivorous animal life is compelled by its likes and dislikes to range widely in order to find what it likes and avoid what it dislikes, and therefore requires and is allowed far more freedom than plant life is allowed. But at the same time herbivorous animal life is, as we have seen, under a prohibition in respect of the likes and dislikes implanted within it which restrict it to a certain range of diet, and also in respect of the nature and

colour of its coat, which give it a certain range of habitation. These prohibitions, as we have seen, are necessary, and, moreover, they are, as we have seen, sternly enforced by means of poisons in respect of range of diet, and by disease in respect of range of habitation.

But, in spite of the direful effects of a long list of poisons and of diseases, the animal might still transgress its allotted range of diet and country. It might begin by taking a little poisonous food, or by going a little way into tracts of country unsuited to it, and find, as man has actually done, that it could gradually harden itself against the ill effects of poisons and diseases.

In spite of poisons and diseases, therefore, the animal might still have transgressed its allotted bounds were it not for the presence of carnivorous animal life, always, in some of its forms, on the watch to pull it down if it weakened itself in any way. We see the machinery of carnivorous animal life now all out of gear owing to man's interference, or, where still working, clogged and hampered at every turn. We can well believe that when carnivorous animal life was in full activity before man's advent, and when none but the fleetest and wariest, or the best concealed amongst herbivorous animals, and amongst these only those which were in full health and vigour could hope to escape, it formed a most effective instrument for preventing

herbivorous animal life from transgressing in any way its allotted range of diet or habitation, and also for compelling it to eat a proper amount of food.

Hence we conclude that carnivorous animal life in full efficiency furnished a most effective controlling agency over herbivorous animal life, not only by preventing it from taking improper food, but also by compelling it to take a proper quantity of its proper food.

To-day, with all the machinery of plant and animal life thrown more or less out of gear, with many of its parts missing, and with most of its parts out of place owing to man's interference, we see it working at a disadvantage under man's control.

We must not judge either of plant life or of animal life by the state of things we see before us now in the world of nature, with everything more or less out of place. The great coal beds show what life, when in full activity, was capable of doing in the way of collecting matter from the atmosphere, and putting it away in the solid form in the earth.

Thus we see that just as plant life meets, as we have seen, a real need, and has not come in casually or accidentally, and herbivorous animal life also meets a real need, so too carnivorous animal life also meets a very real need.

CHAPTER VIII

MANKIND

WE have tried to show that in the building of our universe there was a need of chemical affinity to build atoms up into molecules; that there was a need of cohesion to build molecules up into masses and bodies; that there was a need of gravitation to build up bodies in the shape of moons, planets, and suns into planetary and solar systems; and that there was a need of plant life to sweep up scattered gaseous masses which had escaped the operations of the other processes. We have seen, too, that there was a need of herbivorous animal life to gather in the matter swept up by plant life, and lastly, that there was a need of carnivorous animal life to control the operations of herbivorous animal life.

But we can see no need of any other process. We have, in fact, a complete machinery for gathering in atoms of matter, working, indeed, under difficulties, owing to antagonism, but still working well.

We look in vain for any need of human agency in the physical world.

In a beautiful world, with its mountain ranges

clothed with verdant forests and smiling valleys buried deeply under luxuriant herbage, with forest and vale actively engaged in taking up gaseous matter from the atmosphere, and with its host of herbivorous animals compelled by their own need to pack up and put away the stores collected by plant life, and with its staff of carnivorous animals controlling the machinery of herbivorous animal life and keeping it in perfect order and efficiency, we can see no need of any further agency. And if we study the effect of man's operations, still more obviously shall we fail to discern any need of human intervention. "The burning up," says Professor Bunge, "of vast forests of wood by man, which has been going on for thousands of years, detracts from the store of fixed nitrogen, to which animals and plants owe their existence; the total of life is no doubt diminished thereby, and the fertility of the soil must decrease."¹

Professor Bunge also remarks that "even if the formation of coal is still going on under the sea, on the other hand carbonic acid is being unceasingly returned to the atmosphere from thousands of chimneys."²

So far, then, as the world of nature is concerned, the principal fact to notice in connection with human agency is the destruction of forests which it occasions.

¹ "Physiological and Pathological Chemistry," translated by Wooldridge, p. 21.

² Ibid., p. 17.

These forests represent, as we have seen, a vast array of solid bodies in the shape of trees which have been built up by plant life mainly out of carbonic acid removed from the atmosphere, and thus represent a stage in the work of condensing matter in which strong corpuscles are engaged.

Man comes in and, burning up the forests, restores by his chimneys to the atmosphere, as Professor Bunge points out, the carbonic acid which was removed from the atmosphere by plant life in building up the forests. And not only does he burn up the forests, but very often he follows this up by measures which prevent the forests from growing again. Plant life is energetic and active, and in many places would soon rebuild the forests were it not that man prevents any such rebuilding being done in order to keep the ground clear for his own crops.

Man, in fact, replaces the vigorously growing forms of plant life, which, if let alone, would naturally occupy the soil, by less robust forms which could not hold their own at all without man's help and constant attention.

Clearing and weeding are aggressive operations overthrowing the order of nature; ploughing and sowing are nurturing operations by which tender food crops are given a fair start.

And not only does man deal thus aggressively with the present work of plant life, but he deals

aggressively also with the past work of plant life ; for, after burning up the forests, or nearly all of them, he has now turned his attention to the coal beds, which represent, as we have seen, the past work of plant life, and consist mainly of carbon removed from the atmosphere by plant life, packed up and securely put away in the solid form in the earth.

Man is now busily engaged in disinterring and burning up the coal, and thus in restoring the carbon and hydrogen of which it is composed, in the form of carbonic acid gas and water vapour, by his chimneys to the atmosphere ; and is thus undoing the past work of plant life.

Man is thus not only undoing the present work of plant life by burning up the forests and preventing them from growing up again in his clearances, but he is also undoing the past work of plant life by burning up the coal.

Thus not only do we find that there is no room for human life among the processes of chemical affinity, cohesion, gravitation, plant life and animal life, by which matter is being collected, packed up and put away in the solid form in the great orbs of the universe by strong corpuscles ; but, on the contrary, we find that human life has its place amongst the opposite processes by which weak corpuscles strive to break up the great orbs and scatter the molecules and dissociate the atoms of which they are built up.

In fact, we see that human life succeeds to all appearance in permanently undoing a part of the work of the strong corpuscles in a way no other process succeeds in doing.

Death at first sight appears to undo very completely the work of life; but Professor Bunge points out that "... No life is lost by the death of the individual; from the decay of the body equivalent new life arises."¹ Death, therefore, only undoes temporarily the work of life; whereas, in regard to man's work in burning up the forests, Professor Bunge, as we have seen above, remarks that "the burning up of vast forests of wood by man, which has been going on for thousands of years, detracts from the store of fixed nitrogen to which animals and plants owe their existence; the total of life is no doubt diminished thereby, and the fertility of the soil must decrease."²

He remarks also that "the destruction of combined nitrogen means the definite diminution of the capital, upon the amount of which the total number of living beings depends."³ Man, therefore, is at war with nature.

In studying plant and animal life as they present themselves to our view to-day, it is necessary to remember that all forms, whether wild or domesticated, are existing under unnatural

¹ "Physiological and Pathological Chemistry," trans. by Wooldridge, p. 21.

² *Ibid.*, p. 21.

³ *Ibid.*

conditions brought about by man's clearances and by man's operations in burning, clearing, weeding, ploughing, and sowing. All surviving forms may be said to have learnt something from man, or, if incapable of learning directly from man, have felt the effects of the change which man has brought about, and adapted themselves to changed conditions, though often not without much suffering endured or inflicted.

We look to-day, in fact, not upon an orderly, but upon a disordered world as far as nature is concerned. We look upon a world in which the balance of life has been disturbed. We see over-fed animals unrestrainedly killing for sport, as we do ourselves, and getting the greatest possible amount of sport out of the process in the absence of any effective control; and on the other hand we see animals, in the absence of their natural food, eating things unfitted for their consumption, selecting portions only of their victims, and leaving them then to perish miserably, half eaten; because the other parts of the machinery of carnivorous animal life which would have mercifully completed the work of destruction, or prevented it, are all wanting.

We inveigh against the cruelty of nature, but the indictment we bring is perhaps an indictment against ourselves. All this is possibly the direct result of our intervention in disturbing by our clearing operations the balance of life.

Man's advent therefore represents a breach of continuity in the order of life. If we proceed to inquire how such a breach of continuity has come about we cannot fail to notice that man as a mere animal represents no breach of continuity. There can be no doubt now that there is an animal side in man. Professor Ernst Haeckel tells us that "by the discovery of this fossil man-monkey of Java the descent of man from the ape has become just as clear and certain from the palæontological side as it was previously from the evidence of comparative anatomy and ontogeny."¹

We see no reason to doubt these conclusions, but they accentuate the breach.

Man as an ape of the anthropoid kind has with other anthropoid apes a place in the order of nature. He is a fruit- root- and shoot-eating, and mollusc- or insect-eating animal living in warm, equable climates where supplies of fruit, molluscs, and insects are available all the year round. He has become what he is primarily by changing his ordinary diet and taking to the use of cooked food.

As an eater of cooked grain and cooked flesh he could find subsistence all the world over, and was no longer tied down to the equatorial tracts where fruit supplies can be obtained all the year round.

It is by eating that all life in the forms we recognise does its appointed work. The plant

¹ "Riddle of the Universe," trans. by J. McCabe, p. 89.

eats up the carbonic acid molecules in the atmosphere; the herbivorous animal eats up the plant; the carnivorous animal eats up the herbivorous animal.

By changing his diet man assumed the cosmopolitan rôle in which we now find him playing, and was enabled to move out from the narrow tract to which as an ape he was confined, and overspread the earth.

With each step of his advance outside the limits of his natural habitat fresh needs arose, and with them came fresh demands upon his ingenuity, and fresh demands upon his powers of observation.

In fact, broadly speaking, it may be said that the difficulties man has had to encounter have made a man of him by the calls they made on his powers of observation and invention. The farther he went from his proper habitat the greater became the difficulties, and the higher grew the man in powers of observation and invention.

History shows us this.

The great centres of civilisation two thousand years ago in Rome and Greece were farther removed from the original habitat, from the equatorial regions, than they were in the Nile and Euphrates valleys two thousand years before: and man advanced proportionately.

And to-day these centres of civilisation have travelled northward, and are still farther removed

from the ancestral home of man than they were on the shores of the Mediterranean two thousand years ago.

In this connection we may notice a remark which Buckle has made: "The first circumstance," says Buckle, "by which we must be struck, is that in America, as in Asia and Africa, all the original civilisations were seated in hot countries; the whole of Peru proper being within the southern tropic; the whole of Central America and Mexico within the northern tropic."¹

Great indeed is the advance which man has made in developing his powers of invention and observation since the last shift northward took place. In fact the man of to-day, with his locomotives, steamships, machinery, and telegraphs, is on a different footing from the man of two thousand years ago. The farther outwards the man has gone the greater have become his needs and difficulties, and the greater accordingly has the man become; but at the same time the more pronounced has become the antagonism between man and nature.

The man of to-day not only clears the lowlands for his food crops and the hillsides to provide himself with timber and fuel, but digs out the great coal-beds—the stores of carbon which nature collected from the atmosphere and put away in the earth—and burns up the coal in his fires. In the process

¹ "History of Civilisation," vol. I. (1857), p. 86.

of fuel-burning, the carbon in the wood and coal which are used as fuel combines with the oxygen of the air, and is converted into carbonic acid gas, and restored in this form to the atmosphere from which it was taken by plant life; and thus the work of plant life is completely undone. Man is, in fact, completely in antagonism with nature. And this antagonism has come about from man's needs—from needs which have arisen from transgressing the limits assigned by nature. This transgression had, we are forced to conclude, its origin in a change of diet, because it could not otherwise have been possible.

We have seen at page 231 that eating is the principal duty of animal life, and at page 219 that all forms of herbivorous animal life from lowest to highest are told off, by their appetites and by their powers of digestion, to eat certain forms of plant life and certain forms only, and that the result is that all forms of plant life receive the requisite amount of attention to keep them in working order.

The animal is inhibited from eating at random by the fact that improper food is poisonous. And in a state of nature this inhibition, as we have seen, is enforced by the presence of carnivorous animal life ever ready to seize any herbivorous animal which weakens itself by eating improper food or by over-eating or by eating too little of its proper food.

The animal, in fact, is prevented from transgressing

by a death penalty rigidly enforced. And man, as an anthropoid ape, was under this death penalty too.

But man has evaded the death penalty by superior consciousness and by the device of cooking food, and in this way making food digestible which otherwise would be indigestible.

But in so doing he disturbs the balance of nature, and puts himself, as we have seen, in antagonism to nature. He has ceased, in fact, to be an animal, and has put himself above nature.

And he has increased and multiplied and overspread the whole earth, and nature is being moulded to suit his ideas.

The main facts are here before us all, and are indisputable and perfectly plain if we fix our attention upon the main issues.

Moreover, this is the account which the Bible gives us of the change which has come over man.

The Bible sets forth man as the last stage in a course of creation by evolution, and therefore the most highly evolved stage. It shows us also that man is in a state of transgression, and that he became a transgressor by eating forbidden food—*forbidden fruit*—and thus overstepping the limitation in his range of diet assigned to him, as to all other animals, under a death penalty.

Science and religion therefore both agree in showing man as an animal in a state of transgression

from eating forbidden food. But if we inquire whether this is all that can be affirmed, we find that both science and religion show us that there is something more in man than the animal nature.

We see, on the one hand, man as an animal in transgression on the side of disorder. We see before us a beautiful world disordered by man's transgression. We see the work of life undone. We see molecules of matter scattered and atoms dissociated, after the atoms had been united and the molecules had been collected and arranged in beautiful forms by plant life.

But, on the other hand, we see man as a moral agent, imbued with orderly instincts and working on the side of law and order, to build up individuals into families and families into nations in the face of opposition and resistance.

We see, in fact, that there is a moral side to man in addition to the animal side, and we see that in the moral side of him he takes part in the struggle between law and order and disorder.

The animal, as we have seen, is a destroyer of the soft parts of plants, which are unfitted to remain, in order that it may gather in the hard parts fitted to endure.

So man destroys as an animal in order that he may gather in as a moral agent, or have, at all events, the opportunity of gathering in. For he may be on the wrong side, both morally and naturally.

Thus there is in man an intellectual life as well as a natural life.

And if we think at all, we cannot doubt that the moral is higher than the animal. The moral is, in fact, an expression of a life outside this world altogether.

Its work lies in the collection of bodies of men who are living higher lives than animal lives under a reign of spiritual law and order.

The purely animal man burning up the forests and the coal-beds to warm himself and cook his food is a thing abhorrent, a thing to be destroyed, as testified by the fangs and claws and poisons which deal death to animal transgressors. The spiritual man is something of transcendent worth.

We see this written in large characters on the face of the earth, with waving forests replaced by miles of slate roofs, with its green glades replaced by dusty streets, with its crystal streams replaced by sewers. And this is going on and every day increasing all the world over. Nature is being defaced to get, not the animal man, but the spiritual man. This is written not only on the face of the earth, and thus on the records of science, but it is written, too, on every page of history. History shows us on all its pages, in the rise and fall of nation after nation, that nations are cast out as soon as they give themselves up to the animal side and forget the moral side, the spiritual side of their nature.

It shows us, too, on the page open before us to-day, that the nations which are prospering and spreading are those which are seeking after knowledge. Material prosperity comes along with intellectual prosperity; but if the intellectual prosperity goes and with it the moral sense, then no amount of material prosperity will save a nation.

History, in fact, sets before us the evolution of the moral life as science sets before us the evolution of the animal life.

But moral order is independent of matter. The wonderful order in our universe has, as we have tried to show, reference to the atom of matter, has reference to a conflict over the possession of atoms of matter, which has for its aim the collection of atoms of matter in an orderly way in buildings of various kinds of molecules, crystals, masses, bodies, systems, planetary and solar, in which the atoms, after they have been brought in, are securely held and kept against all the efforts of opposing energies which are ceaselessly striving to break up and scatter bodies, masses, crystals, and molecules.

But the moral order, with the families and nations through which it operates, has no reference to the atom. It has reference to the development of the moral side of man. Its structures are intended to keep the man safely after the moral life has been developed in him, in the face of opposing influences tending to break up nations and families and to

quench the moral life and substitute for it the animal life.

The natural order and the moral order both have reference to antagonism.

But the natural order has reference to an antagonism inside this universe, while the moral order has reference to an antagonism outside, or at all events outside the bounds of the natural order.

The moral order carries the conflict outside this universe, or at all events outside the bodies of which the universe at present consists, and herein manifestly lies its worth.

Here we have an explanation of the fact that man, while undoing the work of nature, is yet allowed to spread and cover the earth.

The natural order, as religion tells us very clearly, and as science tells us also most surely, has no permanence, but is one day to be dissolved and replaced by a new order: "Yea, all of them shall wax old like a garment; as a vesture shalt thou change them, and they shall be changed" (Ps. cii. 26).

But the moral order will, as religion tells us, remain, and be accentuated by the casting out of moral disorder into a place reserved for its occupation at the Day of Judgment and final separation. The work of nature will be dissolved, but man's work as a moral agent will be taken account of on this Day of Judgment.

But now, if we inquire from science whether such things can be possible, we shall have to go back to first principles.

Science, as we have endeavoured to point out, shows us two realities as present in this universe: matter and energy; matter absolutely inert and energy always active; matter in the shape of minute solid bodies, called atoms; energy in the shape of minute fluid corpuscles, called monads by Leibnitz and agents in nature by Newton, endowed with consciousness and desire in a low form.

The antagonism manifest in our universe is between fluid corpuscles of two kinds over the possession of atoms of matter. Corpuscles of the strong kind hold together and co-operate with each other, while those of the weak kind compete with each other for the possession of atoms, and do not hold together, although, like the strong corpuscles, they are able to hold on to atoms of matter.

But if, now, a single strong corpuscle takes on to itself a number of strong corpuscles, until it is completely enclosed on all sides by a company of strong corpuscles holding on to each other and also all holding on to and held by the strong corpuscle in the middle of the group, it is plain that we shall then have a closed system of fluid corpuscles, a fluid body, existing independently of matter. At the same time this system will conceivably be able to offer resistance to any action from outside tending to displace any of

the corpuscles of which the group is made up. The system will also conceivably be conscious, through the central corpuscle in the group, of any interference from outside tending to displace any of the corpuscles in the group, and of external strains due to stimuli which lead to additions being made to any part of the group by activity being excited in the corpuscles on the outside of the group at that particular part. But though the system would resist the displacement of any of the corpuscles of which it was made up by any outside action, it might conceivably yield to such outside action so far as to undergo distortion at the part affected, and to retain in its form so distorted a permanent record of the effects of the action which distorted it. The system might also have in additional corpuscles taken on at parts which had been excited to activity by stimuli a permanent record of the effects of the stimulations which it had undergone in the shape of abnormal outgrowths of corpuscles.

But a distortion on one side might conceivably be obliterated in part or altogether by an effort on the part of the central corpuscle to extend or retract itself, and the corpuscles connected with it on the side on which the distortion was situated, so as thereby to fill up any hollow, or bring down any prominence due to the distortion, and thus level off the surface. Since, however, corpuscles are constant in volume, though

changeable in form, it is plain that the act of obliterating a distortion on one side by an effort on the part of the central corpuscle would give rise to the production of a precisely similar distortion on the opposite side; and thus it is conceivable that the production of the new distortion might reproduce the same effects on the group as the original distortion produced.

Hence it is conceivable that a distortion once produced in the system could be transferred from one side to the opposite side of the system with a reproduction each time of the effects which attended the original formation of the distortion, provided that the central corpuscle was able to make the necessary effort. In fact, the change of configuration which the system undergoes when its form is permanently modified by the distortions it suffers may conceivably constitute the experience, or rather a portion of the experience, of the system. In such case experience will take the shape of a permanent record by distortions of the effects produced on the system from actions outside.

A transfer of any one of these distortions from side to side by an effort on the part of the central corpuscle, with the reproduction of the effects which attended the production of the original distortion, will constitute an effort of *Memory* on the part of the system. In such a case, all that it has done or suffered of sufficient importance to

leave marked effects upon it, or, in other words, all that has interested it, can be brought back to recollection by efforts of memory. But it is conceivable that the system may have a normal activity under which, as a whole, it will have a regular and uniform growth by taking on additional corpuscles all over its surface, in addition to the abnormal activity by which irregular outgrowths of corpuscles are formed at such parts of its surface as are excited by stimulations from time to time. And it is also conceivable that, in a normally growing system, the distortions caused by outside action, and the abnormal outgrowths due to parts of the surface being stimulated, and thus abnormally excited to activity, would all in course of time be covered up and buried under fresh layers of corpuscles taken on by normal growth after the distortions or outgrowths had been formed.

But though the original distortions and outgrowths would be covered up, the irregularities of configuration, due to these distortions and abnormal outgrowths, would remain upon the surface of the group, and could be transferred from side to side; and, therefore, it is clear that the group would retain its experience and memory of the past underlying an experience and memory of the present.

There would, however, in such a case plainly be a difference between past and present experience. For experience of the past, buried under layers

of corpuscles, would be deeply seated, and would thus require a greater effort of memory to reproduce it than the shallow experience of the present would require. Besides this, the distortions representing experience of the past might in course of time be modified in part by other distortions or outgrowths superimposed upon them from time to time. In such a case, in course of time, the reproduction by memory of the events they represented would be less clear and distinct than they were at first, especially if they were allowed to be dormant, and not transferred very frequently from side to side.

Hence the experience of past events would be distinguishable in memory from present experience, both by the greater effort which would be required to recall past experience, and also by want of clearness and vividness which would be apparent in memory in connection with past events.

The status of the system of corpuscles will conceivably be modified if it takes to itself a crust or framework of inert atoms of matter, because it will become, when thus loaded and stiffened, less mobile and less plastic, and therefore better able to give and take heavy blows, and thus to interfere in the building of the universe than it was able to do before. It will lose activity, but gain in solidity. The modification thus effected will manifestly be more marked if the

atoms of matter so taken on are partly held by weak corpuscles which tend to scatter the atoms. For in such a case the atoms of matter may have to be coerced in order to get and keep them together, in their proper places in the crust or framework.

In other respects, however, the condition of the system of corpuscles might conceivably remain unaltered whether it retained its material frame or body, or whether it dropped it and resumed its original form.

The system might conceivably have all along its experience and its memory unimpaired except by having when in a material form its sensibility blunted and its activity diminished.

We can follow by physical phenomena in some measure the effect to the system of taking on a material body. We know that a drop of water may be converted into a solid crystalline mass simply by taking on a number of molecules of matter. For example, we learn from chemistry, that if the drop of water takes to itself a sufficient amount of the substance known as potassium aluminium sulphate to give one molecule of the sulphate to every twelve molecules of water, it will be converted into a mass of ordinary alum which forms transparent octahedral crystals.¹

By heating the alum so formed, the water can

¹ Victor von Richter's "Inorganic Chemistry," translated by E. F. Smith, p. 356.

be driven off and again recovered by distillation unaltered, and the alum will be left behind in the form of a white powder known as burnt alum.

Thus we see that the fluid drop of water is converted into an inert solid mass by taking on atoms, in the shape of molecules of matter, but is otherwise unaltered, so that it is able to resume its ordinary form, viz. that of a drop of water, when it puts off the load of molecules of alum which keep it solid and inert.

So, too, we conclude that our system of strong fluid corpuscles would retain its experience and memory unaltered after it had laid aside a bodily frame. But now, if we refer to Professor James Ward's work, we shall find that the experience and memory with which, as we conclude, a system made up of fluid corpuscles would be furnished, would be essentially of the same kind as the experience and memory which each of us possesses.

We may notice, in the first place, that Professor James Ward points out that "*Sensations have form; in other words, they have inalienable characteristics, quality, intensity, extensity. . . . Again, they are not isolated, but, as I have already urged, they are changes in what—for want of a better word—I have been fain to call a presentational continuum.*"¹ And in connection with this remark, we may point out that the surface

¹ "Naturalism and Agnosticism," vol. ii. p. 116.

of a group of fluid corpuscles supplies a presentational continuum on which sensations may take form if connected with distortions produced upon the surface by displacement of corpuscles by pressure or tension, or by shocks, or if connected with abnormal outgrowths produced by parts of the surface being stimulated to abnormal activity in taking on corpuscles or atoms of matter.

In the next place we find Professor Ward remarking that, "It has always been a difficult problem for psychology—this hold on the past secured by memory; and few are the psychologists who have realised what a fundamental fact it is. Far too commonly it is imagined that memory is mainly a matter of retentiveness. . . .

"Apart from the activity and interest of the subject, there is no evidence of retentiveness, whatever be the physical intensity of the stimulus, or however frequent its repetition. Nor is the so-called 'retention' in the least comparable to the unchanged persistence of an effect, or to the preservation of goods in a storehouse safe from the teeth of time. On the contrary, we only retain what we change; in other words, what we assimilate. If the old merely persisted, we should have an accumulation as fruitless as a miser's store. Or, if the past merely recurred again unchanged, it would be indistinguishable from what is simply present;

to be known as past it must bear the marks of the past about it, marks which it obviously could not have had when first present."¹

But our system of corpuseles has its past experience in the shape of the distortions and abnormal outgrowths wrought in or on it by external causes deeply buried, and thus more difficult to reproduce by transfer to the opposite side than its shallow experience of the present; and has its past experience blunted and modified by after experience overlying it, and therefore its record less clear and sharp than the records of present experience. It is therefore able to distinguish past from present, both by the greater effort required to reproduce impressions or expressions of past events, and the blurred and dim reproductions which it obtains.

Again we find Professor James Ward remarking that "thinking is doing, and like all doing has a motive, and has an end."² And again remarking that "thinking, at any rate, is an arduous labour."³ But our system of corpuseles can think by making use of the experience in the shape of records of events which it possesses. For by bringing the experience of one event to the same side as its experience of another event, and then reproducing these experiences by memory side by side, it is

¹ "Naturalism and Agnosticism," vol. ii. pp. 156, 158.

² *Ibid.*, p. 189.

³ *Ibid.*, p. 220.

conceivably able to institute comparisons between them, and thus form judgments, or "make up its mind," as we say, about them. Its thinking is therefore doing by efforts exerted in the face of resistance, and is thus thinking of the kind to which Professor Ward's conclusions point, since it is not done without effort, and therefore without labour.

We may notice also that Professor Karl Pearson has remarked that "the store of past sense-impressions, our thoughts, and memories, although most probably they have, beside their psychical element, a close correspondence with some physical change, or impress in the brain, are yet spoken of as *inside* ourselves;"¹ and point out that our explanation attempts to show the nature of the physical change connected with memory and thought.

We may also notice that Professor Karl Pearson has remarked that "a sense impression, if sufficiently strong, leaves in our brain some more or less permanent trace of itself,"² and take the opportunity of pointing out that our explanation attempts to show the nature of the permanent trace a sense-impression leaves.

Hence we find that the broad psychological facts in regard to sensation, experience, memory, and thinking, find a physical interpretation or expression in a system of strong corpuscles. We are concerned here with broad facts only; the minor facts which

¹ "Grammar of Science," second edition, p. 61. ² Ibid., p. 41.

Professor Ward's work brings out can therefore be dealt with hereafter.

The point for present consideration is the broad fact, that in a system of strong corpuscles ranged about a single central corpuscle, we may conceivably have a potent body able to grow by taking on strong corpuscles which voluntarily come to it, or by capturing and coercing weak corpuscles which oppose; and able also to take on to itself atoms of matter and form for itself, a covering or a crust, or a solid framework of atoms of matter to give weight to the blows it deals to other bodies which have taken bodily frames like itself, or to the masses of matter about it.

Strengthened thus by a solid framework of atoms of matter, or by a dense covering, the system of strong corpuscles may conceivably be able to interfere actively in the affairs of the universe as a destructive agent, breaking up by the blows it delivers, masses of matter or other bodies like itself; and constructively by building up directly its own shell or skeleton, or by building up indirectly the shell or skeleton of some other body growing out from itself, and thus its true offspring. We may thus conceivably have not only a potent body which is able to destroy: but also a body with an experience, on which is recorded all of importance that it has done, and that it has suffered, and also with a memory by which to peruse the record of

experience; and therefore able to give account of its actions, and able also to form accurate judgments in regard to present circumstances by comparing present experience with past experience recorded within it. At the same time, the body of strong corpuscles, though dependent on its shell or skeleton for its destructive powers, exists with its moral body and its experience and memory and thinking faculty, independently altogether of its shell or skeleton or material body. It can lay aside its material body with its shell or skeleton without laying aside any part of its experience and memory. In fact, the record of all that was done in the material body—in the flesh—will remain, though the flesh is laid aside. We have now an explanation which shows how a man with a body formed of strong corpuscles may, in the flesh as an animal, conceivably work destructively in the universe, and at the same time, as a moral agent, may work constructively in building up families and nations, and forming an orderly and law-abiding population by coercing the unruly, if need be, by blows.

With this explanation we can also see how man, as a moral agent, may consciously take to disorderly courses, and range himself on the side of anarchy and disorder.

We can thus see how it may conceivably be possible for a man to take sides consciously in a

moral antagonism, in the shape of a struggle between spiritual good and evil, in which as a mere animal he can take no part.

Now all forms of religion tell of antagonism between good and evil, and of a conflict between these two as two mighty powers striving for the soul of man.

Science, as we have been trying to point out, shows a conflict over the possession of the atom between natural forces, tending to gather in atoms in an orderly and regular way, and bring them under a reign of law and order, and forces tending to scatter and reduce to disorder and chaotic motion.

Religion tells us of a conflict over man's soul between spiritual forces tending to gather and bring him in under a reign of law and order, and other spiritual forces on the side of anarchy and disorder.

And history confirms the teaching of religion. "Of such stuff," says Carlyle, in view of certain remarkable historical facts, "are we all made; on such powder mines of bottomless guilt and criminality—'if God restrained not,' as is well said—does the purest of us walk. There are depths in man that go the length of lowest Hell, as there are heights that reach highest Heaven."¹

And not only is the reality of the conflict between

¹ "French Revolution," vol. iii. Book I. Chap. IV.

forces on the side of law and order and forces on the side of anarchy and disorder shown clearly in the pages of history, which record episodes such as that of the French Revolution, but it is also shown clearly on the pages which record the ordinary facts connected with the lives of nations. In all nations at all times and in all places criminal classes have existed in the midst of every community of peaceable, law-abiding citizens, kept down only by force, breaking out into open violence whenever the reins of authority were loosely held.

So teaches history in setting forth the facts connected with the lives of nations.

But the history of the life of each sane man or woman, as recorded in the individual experience of each, tells the same fact also. It tells us of restraints which have constantly and continuously to be imposed upon desires urging to excess, urging to disorderly courses, and leading to the ruin of the moral life of the individual if unrestrained.

Christianity has to a large extent lost sight to-day of the reality of this conflict, but in so doing it has disregarded the teaching of its Founder. It has also disregarded the teaching of history, as shown in the records both of the lives of nations and of the lives of individuals. It has, moreover, in this disregarded also the teaching of science. Professor Ernst Haeckel has made this clear with no bias in favour of religion.

"In Christian mythology," he says, "the devil is scarcely less conspicuous as the adversary of the good deity, the tempter and seducer, the prince of hell, and lord of darkness. A personal devil was still an important element in the belief of most Christians at the beginning of the nineteenth century. Towards the middle of the century he was gradually eliminated by being progressively explained away. . . . To-day the majority of educated people look upon 'belief in a personal devil' as a mediæval superstition, while 'belief in God' (that is, the personal, good, and loving God) is retained as an indispensable element of religion. Yet the one belief is just as much (or as little) justified as the other. In any case, the much-lamented 'imperfection of our earthly life,' 'the struggle for existence,' and all that pertains to it, are explained much more simply and naturally by the struggle of a good and an evil god than by any other form of theism."¹

In this connection we may notice a remark Carlyle has made: "In our age," he says, "of Downpulling and Disbelief the very Devil has been pulled down, you cannot so much as believe in a Devil."²

We may also notice another remark which shows that he himself believed in the existence of the Devil. "Truly," he says, "a Thinking Man is the

¹ "The Riddle of the Universe," translated by J. McCabe, p. 286.

² "Sartor Resartus," Book II. Chap. VII.

worst enemy the Prince of Darkness can have; every time such a one announces himself, I doubt not, there runs a shudder through the Nether Empire; and new Emissaries are trained with new tactics to, if possible, entrap him and hoodwink and handcuff him." ¹

And in the same connection we may notice also a remark Mr. Herbert Spencer has made in reference to the harm and suffering wrought by parasites. "With the conception," says Mr. Herbert Spencer, "of two antagonist powers which severally work good and evil in the world, the facts are congruous enough. But with the conception of a supreme beneficence this gratuitous infliction of pain is absolutely incompatible." ²

We may further notice that Sir William R. Grove, also from the scientific standpoint, remarked in a lecture on Antagonism that "undoubtedly good and evil are antagonistic." ³

It is therefore clear that the renunciation by Christianity of a belief in a conflict between two antagonist powers of good and evil is not warranted by scientific or by historical facts, and most certainly is not warranted by the records of religion. Professor Ernst Haeckel points out that "in ancient India, Vishnu, the preserver, struggles with Siva, the destroyer. In ancient Egypt, the good Osiris is

¹ "Sartor Resartus," Book II. Chap. IV.

² "Principles of Biology," vol. i. p. 429, revised edition.

³ *Nature*, vol. xxxvii. p. 618.

opposed by the wicked Typhon. The early Hebrews had a similar dualism of Aschera (or Keturah), the fertile mother-earth, and Elion (Moloch or Sethos), the stern heavenly father. In the Zend religion of the ancient Persians, founded by Zoroaster, two thousand years before Christ, there is a perpetual struggle between Ormuzd, the good god of light, and Ahriman, the wicked god of darkness."¹ While the records of the Christian religion show that the conflict is so severe that when Man went astray through his desires, and went over to the side of evil, it was necessary, in order to rescue him, that One who shared in the Godhead should take Man's form, and while Himself obeying in all respects the Father's will, should undergo the penalty of Death in the cruellest of all forms as a representative man.

Death, as we have been trying to show, is the penalty for unfitness, and the penalty for transgression, as recorded in the boldest of characters across the face of nature by a long array of poisons, by a host of death-dealing forms, pathological bacilli, parasites, felidæ, and others pulling down the unfit, exacting the death penalty upon the transgressor.

But the records of Christianity show that the Lord Jesus Christ underwent the penalty of death in the full vigour of manhood, and therefore for no physical unfitness, and moreover underwent the

¹ "The Riddle of the Universe," translated by J. McCabe, p. 286.

penalty as a righteous man, and therefore for no transgressions of His own, as testified by His judge, "I find in Him no fault," said Pilate (John xviii. 38).

But man, as we have shown, is out of place in this universe—is in transgression. He is in transgression in his physical nature, as shown by the records of science. And, moreover, he is in transgression also in his moral nature, as shown by the records of history. "There are," as Carlyle shows from the records of history, "depths in man that go the length of lowest Hell."¹

And Jesus underwent death, not in old age on account of physical unfitness, not merely death in one of its ordinary forms, as a man for man's physical transgression; but He underwent death in the cruellest of all forms, on account of man's moral transgression also. The record is that Pilate "knew that for envy they had delivered Him" (Matthew xxvii. 18).

We have seen at page 254, that Professor Ernst Haeckel has pointed out that Christianity has explained away the personality of the evil one.

But in the records which tell us that when man had sinned, and by his transgression gone over both physically and morally to the side of the evil one, it was necessary in order to save him that the Son of God should endure the cruellest of all deaths—

¹ "History of the French Revolution," vol. iii. Book I. Chap. IV.

the worst the enemy could do—we have no making light of the power and malignity of the evil one.

In fact, the recognition is so complete that some have held that the representation, if closely looked into, involves a recognition too tremendous for belief, and that it is incredible that such a drama as that involved in the scheme of man's redemption should have been acted on such a tiny speck in the universe as is our earth.

This objection, of course, fully recognises the fact that Christianity of old made much of the might and malignity of the evil one. But at the same time it is an objection which was ages ago formulated and met. "When I consider," says the writer of the Eighth Psalm in our Bible, "Thy heavens, the work of Thy fingers, the moon and the stars, which Thou hast ordained; what is man, that Thou art mindful of him? and the son of man, that Thou visitest him? For Thou hast made him a little lower than the angels, and hast crowned Him with glory and honour. Thou madest him to have dominion over the works of Thy hands; Thou hast put all things under his feet: all sheep and oxen, yea, and the beasts of the field; the fowl of the air, and the fish of the sea, and whatsoever passeth through the paths of the seas" (Psalm viii. 3-8).

Here we manifestly have the objection formulated, and the admission in effect made, that man and his works and world sink into entire insignificance if

they are viewed in comparison with the universe at large with its immense star-strewn space.

But at the same time it is in effect pointed out that this is a hopelessly wrong view to take of the case, because the standard of comparison is altogether faulty. For man has no cosmic value as a builder; his vocation is to be a ruler—"Thou madest him to have dominion."

Man's value must not be judged of by building standards but by controlling standards. The mighty energies of nature which have built the vast universe can even now to some extent be ruled by man, can be brought into subjection by man, and forced to work for him. Their vastness makes man's importance the greater, as being their possible ruler, instead of making him sink into insignificance, as the objection would make out.

We shall judge more correctly of the case if we keep in view the ceaseless and the determined efforts which the evil one makes to ruin man and deprive him of his kingdom. In these ceaseless efforts and in this malignity we may see a recognition of man's high worth and importance.

"O purple Sovereignty . . . what a thought:" says Carlyle, "that every unit of these masses is a miraculous Man, even as thou thyself art; struggling with vision or with blindness for *his* infinite Kingdom (this life . . .) . . .!"¹

¹ "History of the French Revolution," Vol. I. Book II. Chap. II

We have seen that science shows us that man as an animal, with wants which compel him to burn up the forests, is a destructive agency, and ranges himself on the side of the energies which break down and scatter. It is only as a moral agent, when he subdues by his knowledge the evil in man and subdues the energies of nature, that man has any cosmic worth. We have found, also, that the whole realm of nature is being sacrificed in order to get this moral agency; and thus that man, in spite of his transgressions, is greatly loved and highly favoured; and thus also that science corroborates the account of religion that "God so loved the world."

We find that men have never understood or recognised their own transgression against the order of nature, and thus against the order of God, in being what they are—in being, in fact, men and not anthropoid apes of the highest class—and in disregarding the arrangements for division of labour which restrict, as we have seen at page 219, each kind of animal to a certain range of diet and of habitation, and are so sternly enforced against herbivorous animals. And not understanding their own transgression, men have been unable fully to understand the account of religion that "God so loved the world that He gave His only begotten Son" that men should not perish.

The records of Christianity show, as we have seen, that the Son of God had to endure at the

hands of men, by the instigation of the evil one, the cruellest death human ingenuity could devise, and thus suffered a reverse. But the point is that it is shown to have been only a temporary reverse, since He rose again to life.

Now the whole progress of Evolution is marked by temporary reverses. We have atoms dissociated after they have been built up into molecules, molecules vaporised and scattered after they have been collected into solid masses, and so on. But these checks are only temporary; the progress of Evolution goes steadily on in spite of them. The whole story of redemption is, in fact, in accordance with the teaching of Evolution.

Evolution tells of the value of the individual in relation to progress. Evolution shows that it is by the advantageous variation of the individual and by the gifted individual, and not from the masses, that help comes to the species.

This is essentially what Christianity teaches, since it tells of a Saviour who, when man had lost by transgression so much of the Divine nature originally given him that he was powerless to resist the evil one, was born upon earth as a man with more of the Divine nature than man ever had; and was able to impart to men a higher knowledge: and is able to give to those who value the higher knowledge and make use of it to seek His help a greater measure of the Divine nature than Man ever had before; and

thus save them from the evil one. Surely this is the completion, the climax of Evolution.

The fact that this Saviour laid down His life and took it again need cause no scientific difficulty. The doctrine of the conservation of energy based upon corpuscles shows, as we have seen, the possible existence of energy bodies with consciousness and desire, able to take on and able to put off, and then again to take on material bodies.

We have now the broad facts before us. They tell us that man is born for dominion outside this world, but only those who are wise will ever exercise it.

This world is the trial ground in which those fitted to exercise dominion are being selected by antagonism—by a stern conflict in which the wise overcome by Divine help, sought for by and given to them, or possibly even given unsought, and the foolish fail by rejecting Divine help. This is the teaching of the broad facts of religion, science, and history according to our views. We are not concerned here with details; these can readily be filled in afterwards. Our work now is to get the outlines clearly laid down.

Our conclusion is that there is no need in the universe, as it exists at present, for man, endowed with knowledge, and, at the same time, a burner of forests; and no possible way of explaining man's retention except for employment in another sphere

in a new universe, in which man's powers of control can be turned to full account; except, therefore, as a being endowed with immortality, and endowed with a memory and an experience gained in this world.

The spectacle before us is that of man diligently engaged in the pursuit of knowledge, and adding so successfully to his stores of knowledge that he is able so far to control the energies of nature, the builders of the universe, as to compel them to work for him. And yet at the same time, the spectacle is that of man unable to control himself, though able, by his knowledge, to control the vast energies of nature; wilfully, blindly destroying himself by drink and profligacy. We see man his own enemy.

We see man, also, with his knowledge, diligently engaged in burning up the forests, and thus not only undoing the work of nature, but also destroying the very capital of life, its stock of combined nitrogen, as Professor Bunge has shown.

"The burning up," says Professor Bunge, as we have already seen at page 226, "of vast forests of wood by man, which has been going on for thousands of years, detracts from the store of fixed nitrogen, to which animals and plants owe their existence; the total of life is, no doubt, diminished thereby, and the fertility of the soil must decrease."¹ Thus we see man with his knowledge the enemy of nature.

¹ "Physiological and Pathological Chemistry," translated by Wooldridge, p. 21.

And not only is man burning up the forests, but he is using his knowledge to get at, disinter, and destroy the great coal beds which have been so carefully got together and put by by nature.

Thus we have the highest out-turn of evolution the enemy of nature, and his own worst enemy too. That is the spectacle before us.

If we can see nothing behind or beyond Evolution, if we can discern no field for the employment of man's great powers of control, and for the employment of his every day increasing stores of knowledge, than this small world, in which man is so hampered by his wants that he can work only destructively, then we have indeed an insoluble enigma.

But if behind evolution we discern a power working through agents to gather in atoms of matter in the face of the resistance offered by another power, and the determined efforts of that other power to scatter the atoms; if we see the difficulty of collecting atoms increasing after the atoms easily gathered in had been collected, and there remained only those which had eluded the earliest attempts to get hold of them; if we see the agencies for collecting atoms strengthened by having larger powers and greater activities conferred upon them to meet the increasing difficulty of laying hold of the atoms; if we see that this went on until, finally, such freedom was allowed to man that he was able to misuse his freedom, and go over to the

side of the opposing power, and scatter instead of gather; if we then see man not abandoned in spite of his defection, but so loved and cared for as to have a way of returning opened up for him, and the offer made to him of a field for the full employment of all his powers and all his knowledge if he fights his way back, the case then is clear enough.

Man, as an animal led astray by his desires, is, in the flesh in this world, on the side of the power which scatters and destroys; but as a moral agent, with his knowledge and powers of control, he can, if he so wills, be outside this world, spiritually or morally, on the side of the power which gathers.

St. Paul puts the case thus: "So then with the mind I myself serve the law of God; but with the flesh the law of sin" (Romans vii. 25).

To sum up. This much is certain: We have got to rule ourselves even if we are not called to rule others. We cannot escape this call to exercise control over rebellious inclinations and desires within us urging to excess and to disorderly courses. We have to control ourselves, be it observed, for our own sakes, for we perish if we fail to control ourselves, as the death of the drunkard shows; and we have to control ourselves for the sake of human society, not for the benefit of the physical world at large.

We are compelled therefore to conclude that the control man is called to exercise has no mundane significance. Its worth is moral and not mundane, spiritual and not material. An evolution, which has its climax in man with his sins and his sorrows, and yet with his vast powers of control, must necessarily have a significance other than a physical significance. If it covered the whole face of the earth with men and their cities, what physical advantage would there be? What gain would there be unless man's work has reference to a hereafter?

In fact, man's work has "hereafter" indelibly branded upon it in the plainest of characters, whether it be good or whether it be evil.

CHAPTER IX

A SUMMARY OF CONCLUSIONS

As the result of our survey we find first of all that the discovery of the existence of inactive elements of the helium, neon, argon, &c., kind has completely altered the outlook for science from a philosophical point of view by taking science down below Evolution, and showing the substantial reality of things at a lower level.

It has done this by showing in inactive elements the existence of atoms with which no molecules can be built, and therefore atoms with which Evolution is powerless to deal; since chemistry shows that molecule building, in which atoms are built up in a regular and orderly way into groups or clusters called molecules, is the first stage in the Evolution of all the masses and bodies about us.

It has then shown from a Periodic System, completed by the addition of inactive elements, that the atoms of these inactive elements with which Evolution is powerless to deal were converted, by undergoing alterations affecting their weight, into the atoms of the active or valent elements, out

of which all molecules are built up, and with which, therefore, Evolution deals. And since our own materials, when in the rough, also undergo alterations which affect their weight to prepare them for building purposes, being dressed and thus cut down, or pieced together and thus added to, it follows that facts before us in the Periodic System accord with the view that the atoms of the inactive elements were prepared for molecule building, and thus for Evolution, by ways analogous to those by which our own materials are prepared: more especially as the Periodic System tends to show, by metalloids atoms made valent by cutting down the weight of the atom and by metal atoms made valent by adding to the weight of the atom, that the same two ways of cutting down and piecing together as are used in our own workshops and yards in preparing our materials for building purposes, were employed in turning inactive atoms into valent atoms.

We are thus shown operations which went on before Evolution appeared upon the scene. And in whatever way we view these operations we are shown also the fact that Evolution does not reach far enough back to account for the origin of the universe, and therefore cannot be used as a foundation for any system of philosophy dealing comprehensively with the universe; and thus also that the outlook for science has been changed from a philosophical point of view.

The whole case, as thus put, turning as it does upon building and manufacturing operations, has more or less of an engineering character about it. For this very reason it is perhaps not reasonable in these days of specialising to expect it to strike the chemist and the physicist so speedily as might otherwise have been expected. It is, therefore, a case which is likely to require much pressure to drive it home. Nevertheless, we find the points in it to be so clear and simple that any one who has eyes and uses them and has also common sense can grasp them without much trouble.

In fact, we believe that it will be found impossible to doubt the cogency of the evidence supplied by a complete Periodic System; when it shows us, as it does, inactive elements giving rise each to a complete family of metalloid and metal elements, such as Neon's family shown in Diagram 1, at page 58, if the case is closely looked into.

It will be found, in fact, that the evidence is so clear that it was possible to discern and point out the possible existence of these inactive elements and the families of valent elements to which they have each given rise before helium, neon, argon, krypton, and xenon were actually discovered by Professor Ramsay and his colleagues. And it will be seen from "Argon and Newton," chap. i., that this was actually done.

The importance of the whole case lies in the

light it throws upon after-events in the history of the universe. For even in the next chapter of that history we still do not come upon Evolution. We find, indeed, from a complete Periodic System every preparation made for molecule building and thus for Evolution by the conversion of the atoms of inactive elements into the atoms of valent elements, of which all molecules are built, yet we do not find any molecule building done in the next stage which science shows us.

In fact, we find that a whole age had still to intervene before any molecule building was done and before Evolution came upon the scene. For science shows us, by the Kinetic Theory of Gases, that in the next stage the atoms of these valent elements were all scattered throughout Space by a kinetic energy which set them flying in all directions independently of each other instead of being brought together and formed into molecules. Thus the scene before us in the next stage is one of chaos and confusion instead of an age of law and order and Evolution, such as that for which the valent atoms had been so carefully prepared.

Hence the purpose for which the valent atoms were prepared, with all the care and precision which the Periodic System reveals to us, has been completely lost sight of, and no molecule building, and no Evolution, is possible now without a complete change.

In fact, energy of attraction, by which atom is

drawn to atom, must replace the kinetic energy by which atoms are set flying in all directions, independently of each other, before any molecule building can be done.

The doctrine of the "conservation of energy" by showing us that energy cannot be destroyed, shows us that the change was not quietly effected by simply quenching or damping the kinetic energy, which kept the atoms flying in all directions, independently of each other, but was effected by dislodging and transferring this kinetic energy, and replacing it by energy of attraction, and therefore by a conflict between two forms of energy over the possession of atoms of matter. Now, it has long been apparent that the universe is the scene of a conflict such as this. Dalton speaks of "two great antagonist powers of attraction and repulsion."¹

Mr. Herbert Spencer, too, tells us very plainly of the existence of such a conflict. "The processes," he says, "thus everywhere in antagonism, and everywhere gaining, now a temporary and now a more or less permanent triumph the one over the other, we call Evolution and Dissolution. Evolution, under its simplest and most general aspect, is the integration of matter and concomitant dissipation of motion; while Dissolution is the absorption of motion and concomitant disintegration of matter."²

¹ "A New System of Chemical Philosophy," p. 144.

² "First Principles," fifth edition, p. 285.

Thus the existence of a conflict has long been clear, but the object of the conflict was not clear. In fact, it appeared to be a meaningless conflict, and thus a mere display or sham-fight, which, in the absence of any apparent reason for its appearance or disappearance, might go on for ever in an alternation of phases of Evolution and Dissolution. "Apparently," says Mr. Herbert Spencer, "the universally co-existent forces of attraction and repulsion, which, as we have seen, necessitate rhythm in all minor changes throughout the Universe, also necessitate rhythm in the totality of its changes—produce now an immeasurable period during which the attractive forces predominating, cause universal concentration, and then an immeasurable period during which the repulsive forces predominating, cause universal diffusion—alternate eras of Evolution and Dissolution."¹

As soon, however, as the idea is grasped that the Periodic System, when completed by the addition of inactive elements, shows that the atoms of all active or valent elements have been prepared with great care and precision for the express purpose of building molecules, and are therefore misused when scattered, as the Kinetic Theory of Gases shows them to have been scattered, we perceive that there is a definite object in the conflict, and that the object is the recovery of the atoms for rightful use in

¹ "First Principles," fifth edition, p. 537.

molecule building from the wrongful use to which they are put when they are scattered.

And when we further realise the fact that chemistry shows us that molecule building is the first stage in a series of building operations by which molecules are built up into masses and bodies by cohesion, and bodies are built up into solar systems by gravitation; and perceive also, from the many beautiful forms about us, in the shape of crystals, flowers, leaves, feathers, scales, &c., that work of the most exquisite loveliness can be done with molecules, even during the stress of conflict, and therefore under conditions altogether unfavourable, it becomes apparent that atoms with which buildings can be put up on such a magnificent scale, and work of such exquisite loveliness can be done, are things worth fighting for, and therefore that the conflict has a worthy object.

We perceive, also, that the conflict is not one which will go on for ever, but a conflict which will come to an end as soon as the atoms have been recovered and turned to full account in the construction of the buildings of exquisite loveliness, for which they were prepared with such manifest care and exactness.

The very fact that work so lovely as that before us, in crystals, flowers, and feathers, should have been done with molecules under conditions so unfavourable as those prevailing at present, suggests

possibilities far transcending in glory and beauty the actualities of the present, marred and disfigured as they are by the conflict, when the conflict shall have come to an end, and atoms shall have been recovered and put together in perfect order. In the fuller light which the discovery of the existence of inactive elements throws upon the situation, we perceive that religion has rightly grasped the facts when it says: "Nevertheless we, according to His promise, look for new heavens and a new earth, wherein dwelleth righteousness" (2 Pet. iii. 13).

We see, in fact, that the necessities of the situation demand the production of new heavens and a new earth.

Having reached this view, we can understand now how and where we ourselves come in, and also the part we take in the conflict.

For it is quite plain that in burning up, as we do, forests and coal beds we are returning to the atmosphere, and thus scattering, the atoms of which the trees and coal are built up. Hence we are undoing the work of plant life by which trees were built up by gathering in atoms from the gases in the earth's atmosphere, and then packing up these atoms in a solid form in leaves, branches, trunks, and roots; and then forests formed with the trees; and afterwards coal beds from the forests.

In thus undoing the work of plant life, which is, as we have tried to show, aided and supplemented

directly or indirectly by all other forms of animal life, we are plainly, on the animal side of us, transgressing against the order of nature.

On the animal side of us we, therefore, take part in the conflict over the atom on the opposite side to that on which all other animals take part.

We range ourselves, in fact, on the side of the energy which scatters the atoms, instead of taking the side of the energy of attraction which gathers in the atoms.

We are thus as animals on the losing side in the conflict, and thus lost. For this energy which scatters is, as we find, being driven out, and will, perhaps, lose possession altogether of the atoms which it has so misused.

But now we find that there is another side to our nature besides the animal side. We find, in fact, that there is in us a moral side.

And we all, that is to say, all sane persons among us who have a knowledge of the difference between right and wrong, know that a conflict goes on in us between two sets of tendencies. One of these sets of tendencies urges us to a wrongful use, and impels us to disorderly courses, to excess, intemperance, and anarchy, and at one time or another have in some shape to be repressed; while the other set of tendencies urges us to a rightful use, and draws us to the side of law and order, and to the side of decency and sobriety. The tendencies

to a wrongful use take different shapes in different cases, but all of us have in some form or other to exert self-control.

But the conflict over the atom is, as we have seen, one for the rightful use against the wrongful use. Hence it is essentially of the same order as the conflict over our moral selves, which turns on a rightful use against a wrongful use.

Hence we conclude that the conflict over our moral selves is connected with the conflict of the universe over the atom.

And we conclude also that the very fact that man, though altogether on the losing side as regards the conflict of the universe, has not been abandoned altogether and left to perish, but is on the moral side the object of a strenuous conflict, affords clear proof that man has a moral worth far higher than his worth as an animal. We see in the animal world in a long array of poisons, and in a display of fangs and claws, that the death penalty is pitilessly enforced against the animal which transgresses the range of diet or the range of habitation assigned to it, as man has transgressed.

But we see man transgressing and not given over to death, but cared for and fought for, and therefore greatly favoured and loved. We are driven, therefore, to conclude that man's moral worth is far higher than his worth as an animal.

Now man's moral worth plainly consists in his

knowledge, and in his powers of controlling and co-operating, whereby he is able, not only to control himself so far as to be able to choose the side he will take in the moral conflict, but able also to control and guide not only other men, but even the forces of nature—the energies by which the universe is being built up or thrown down—so far as to compel them to do much work for him.

If we examine human institutions, whether of the family, social, or national kind, we see that they have for their object the training of men in knowledge, in habits of self-control, and in methods of co-operation, or else they tend in the opposite direction to degrade men.

In fact, we find men year by year growing in knowledge and in powers of controlling the energies of nature, and likewise growing stronger in the art of destruction.

It is, as we have seen, for man's moral worth that he is fought for and loved.

And yet we find that in the conflict of the universe—the conflict over the atom—man takes the losing side just as much on the moral side of him as he does on the animal side of him. He uses his knowledge and his power of controlling the energies of nature to put up buildings in opposition to gravity, and in opposition, therefore, to the energies of attraction; and to destroy the forests and coal beds.

His buildings have no cosmic value; in a few thousands of years at the outside they will all be pulled down.

Why, then, is man fought for and cared for, and allowed to overspread the earth and overturn the order of nature instead of being given over to destruction in his transgressions, as the animal transgressor is given over. It cannot be for any worth that man has here, either on his animal or on his moral side, that he is fought for and loved by the leader of the hosts of the energy of attraction. The conclusion is inevitable that it can only be for employment in another sphere that man is wanted.

In the new heavens and the new earth there may conceivably be full scope for the employment of man's knowledge and powers of controlling.

Life, then, here is a sifting process, a process of sifting out the wise from the unwise, and those who have learnt to control themselves first, and then others from those who cannot control themselves.

In this connection it is worth while to consider how the whole earth is being overspread by the nations who are in search of knowledge and love knowledge, to the exclusion of those who despise knowledge. Consider how deeply seated in human nature is the desire to control. Consider how all history is one long record of man's love of controlling, or hatred of being controlled, if there is any capability in him.

In the light of such facts we may learn something in regard to what is wanted of man, and wherein man's worth consists.

But these conclusions show that man's moral worth is independent altogether of the material body he wears here and endures after the body has been laid aside.

We have tried in the preceding chapter to show how this may be. We have tried to show that the strong corpuscles, the parts of the energy of attraction which hold together and co-operate with each other to gather in the atoms and build them up into molecules, masses, &c., may group themselves about a strong central corpuscle, and holding on to it form closed systems, capable of yielding to shocks sufficiently to undergo permanent deformation and change of configuration without breaking up. Such a system in the indentations or distortions formed on its surface by shocks would have a record in itself of what it had gone through, and thus an experience of the past.

Now, if the central corpuscle of this system fills up one of these indentations by extending itself towards the side on which that indentation lies, it will have to take correspondingly from the substance on the other side, and thus will have to reproduce the indentation on the opposite side. In this way, therefore, it can conceivably reproduce the effect of any shock by transferring the recorded effects of

that shock from side to side. In other words, the system will have a memory in the shape of a way of reproducing its experience of the past.

Since there is nothing to prevent such a system from attaching itself to atoms of matter with or without change of configuration, it could conceivably take on to itself a covering of atoms, and thus a body without losing its experience and memory, and could in like manner lay aside this body without loss of experience or memory. The system would, in fact, have immortality if the central corpuscle were strong enough to hold the system together against all shocks and strains which could possibly affect it. The system would have a valency or worth for building purposes, since it could pick up atoms and put them down again.

On the whole, therefore, we find that Evolution throws no light on the origin of the universe as it is exhibited to us by a Periodic System completed by the addition of inactive elements; while, on the other hand, we find that the account of Creation given in the Bible agrees essentially with the account which the Periodic System gives.

We see, also, that Evolution in its proper place correctly indicates the subsequent stages of creation, and throws light on the account given in the Bible.

We find too that science confirms the account of man's transgression given in the Bible, and shows also the correctness of the Biblical account that

man was not abandoned in spite of his transgression, but is earnestly fought for, and greatly loved and favoured. We find also that the account in the Bible of man's rescue effected in the same way as the atom was rescued by victory gained in conflict; of his redemption by payment of the death penalty incurred by man's transgression; and of his restoration by a way being opened for man's return by a perfect Man, who knew no sin, and thus by a Catalyst, so to speak, corresponding to the catalysts¹ shown to us in chemistry by Professor Ostwald's work, is an account which meets and provides for the necessities of the case, so far as they are disclosed to us in science.

¹ "Nature," vol. lxx. p. 522.

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